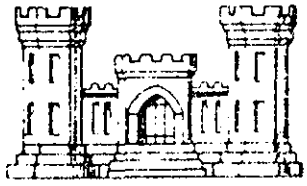
5/27/80

RICHELIEU RIVER BASIN
HYDE PARK, VERMONT

GREEN RIVER RESERVOIR DAM
VT 00024
GREEN RIVER RESERVOIR DIKE
VT 00246

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

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14. ABSTRACT
The Green River Dam is a concrete arch dam 360 feet long and 97 feet high. This dam along with a 248-foot long and 23-foot high dike located 1.4 miles southeast of it create an impoundment with a surface area of 620 acres and normally containing about 17,520 acre-feet. This reservoir ponds water from the 13.8 square mile hilly, forested, drainage basin. The dam is used for flow augmentation purposes by the Morrisville Water and Light Department.

Flows from the reservoir are normally regulated by a 6-foot diameter "Dow" valve on a 5-1/2-foot penstock which connects to a 30-inch discharge conduit. The spillway is a 60-foot wide ogee section in the center of the dam. All flow released from the dam whether from the 30-inch discharge conduit or from the spillway, enters into an 11-foot deep and 180-foot long stilling basin impounded by a concrete gravity weir 79 feet long and 18 feet high.

The Green River Dam, overall, is in good condition, but is judged to be in fair condition because of the overtopping potential of the test flood.

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Dams, Inspection, Dam Safety, Richelieu River Basin, Hyde Park, Vermont

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GREEN RIVER RESERVOIR DAM

VT 00024

GREEN RIVER RESERVOIR DIKE

VT 00246

HYDE PARK, VERMONT

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No:	VT 00024 Dam, VT 00246 Dike
Name of Dam:	Green River
Town:	Hyde Park
County and State:	Lamoille County, Vermont
Stream:	Green River
Date of Inspection:	April 30, 1979

BRIEF ASSESSMENT

The Green River Dam is a concrete arch dam 360 feet long and 97 feet high. This dam along with a 248-foot long and 23-foot high dike located 1.4 miles southeast of it create an impoundment with a surface area of 620 acres and normally containing about 17,520 acre-feet. This reservoir ponds water from the 13.8 square mile hilly, forested, drainage basin. The dam is used for flow augmentation purposes by the Morrisville Water and Light Department.

Flows from the reservoir are normally regulated by a 6-foot diameter "Dow" valve on a 5-1/2-foot penstock which connects to a 30-inch discharge conduit. The spillway is a 60-foot wide ogee section in the center of the dam. All flow released from the dam, whether from the 30-inch discharge conduit or from the spillway, enters into an 11-foot deep and 180-foot long stilling basin impounded by a concrete gravity weir 79 feet long and 18 feet high.

Based on the intermediate size and high hazard classification, in accordance with "Recommended Guidelines for Safety Inspection of Dams," the test flood for this dam is the Probable Maximum Flood (PMF). The test flood inflow of 36,300 CFS (2,623 CSM) produced a routed test flood outflow of 18,400 CFS which overtops the concrete arch by 5.5 feet and overtops the dike by 0.5 foot. With water level at the top of the dam, the spillway capacity is 2,600 CFS or 14 percent of the routed test flood outflow.

The following significant conditions were observed:

1. The concrete is in good condition with some spalling and a few holes on the dam face.

2. Access gates on the dam crest and locks from the doors to the intake valve house have been removed.

3. Seepage at the right abutment contact of the dam to the ledge is still in evidence as was reported in 1953.

4. There were small trees and brush growing on the dike faces.

5. The water level was so low that a complete assessment of the seepage from the dike could not be made at this time.

The Green River Dam, overall, is in good condition, but is judged to be in fair condition because of the overtopping potential of the test flood. The dike is judged to be in fair condition based on previous inspection observations of a large seep through the glacial till foundation. A detailed assessment and recommendations for remedial action are contained in Section 7 of this report. In summary, it is recommended that the following actions be instituted under the guidance of a registered professional engineer qualified in dam design, within one year of the receipt of this report:

1. Repair the spalling concrete and holes found on the face of the dam.

2. Replace the abutment crest access gates and provide vandal-proof locks on the valve house doors.

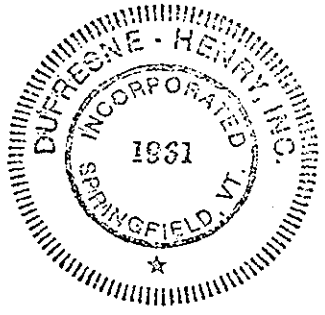
3. Cut the brush and small trees from the face of the dike on an annual basis.

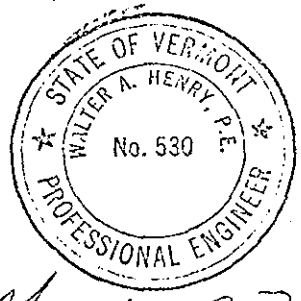
4. Monitor and record the quantity of seepage at the right abutment contact.

5. Reinspect the dike when the water level is at its normal level.

6. Prepare a formal warning plan and round-the-clock surveillance system during periods of unusually heavy precipitation or high project discharges.

7. Prepare a detailed hydrologic and hydraulic analysis of the spillway capacity and evaluate the ability of the dam to withstand overtopping.





Walter A. Henry

This Phase I Inspection Report on Green River Reservoir Dam and Dike has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

JOSEPH A. MCELROY, CHAIRMAN
Chief, NED Materials Testing Lab.
Foundations & Materials Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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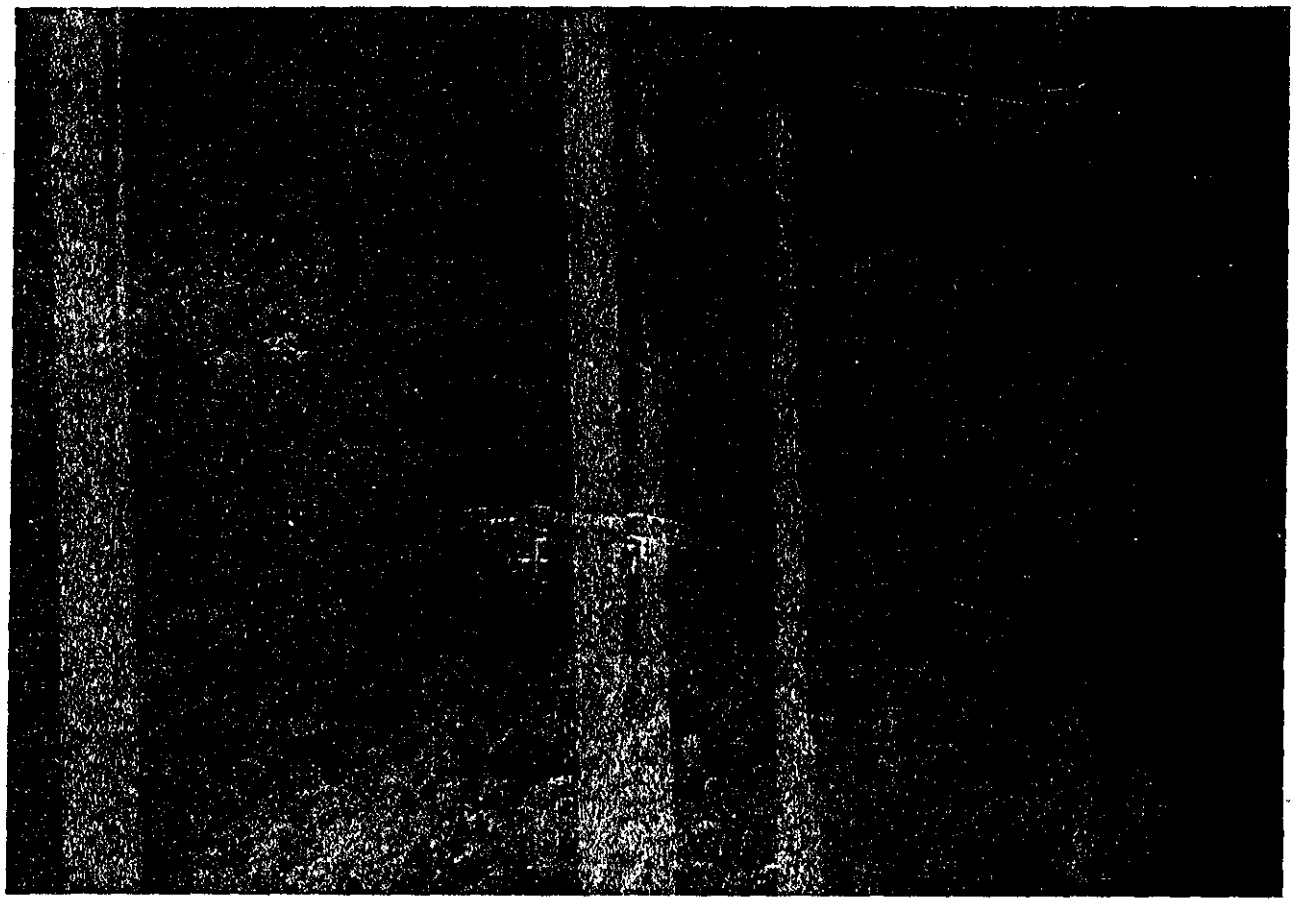
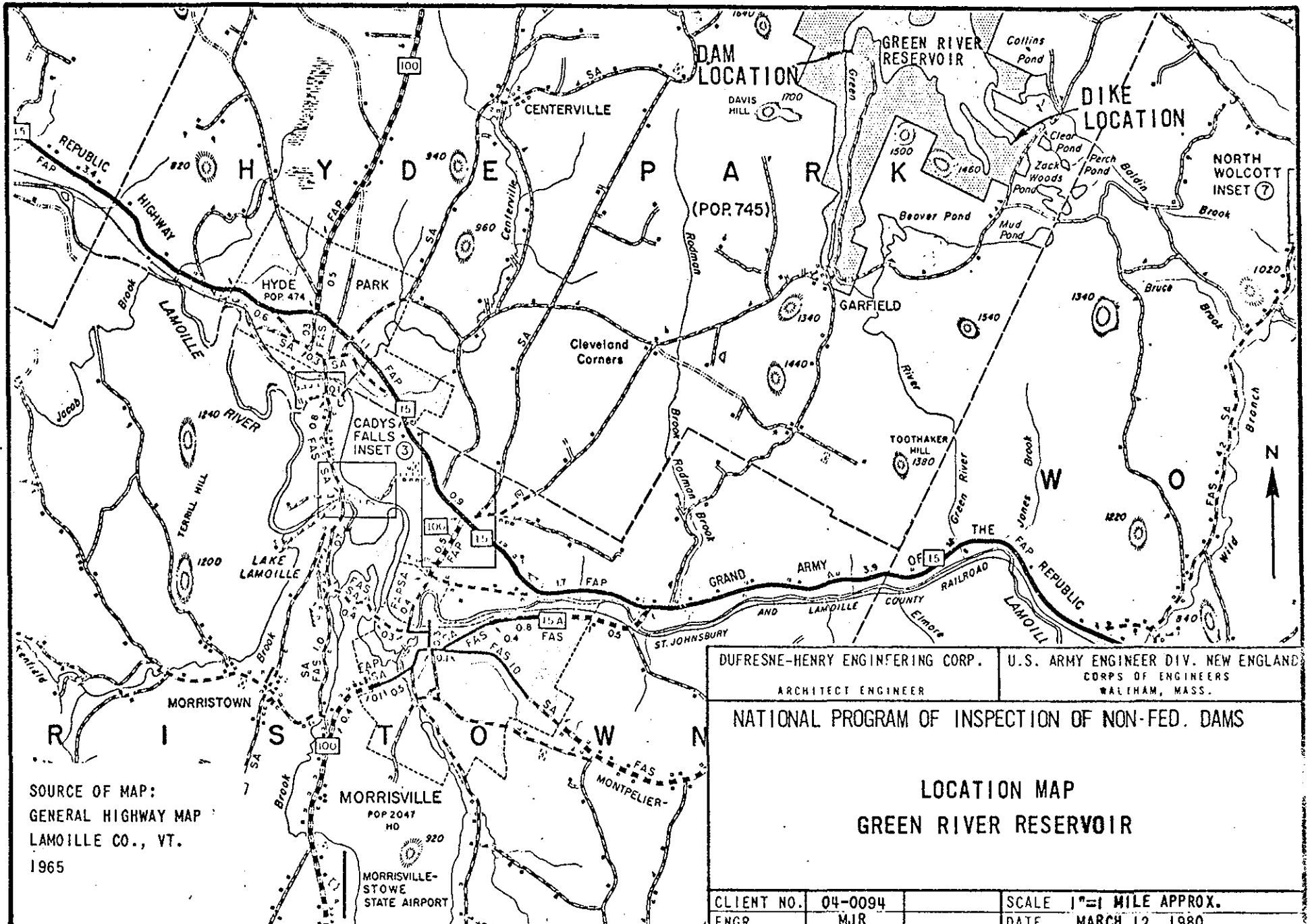


OVERVIEW OF
GREEN RIVER RESERVOIR DAM
HYDE PARK, VERMONT


DAM LOCATION
GREEN RIVER RESERVOIR
DIKE LOCATION
NORTH WOLCOTT INSET (7)
CENTERVILLE
DAVIS HILL 1700
Collins Pond
Clear Pond
Perch Pond
Zack Woods Pond
Baldin Brook
Beaver Pond
Mud Pond
H Y D E P A R K
(POP. 745)
HYDE POP. 474
PARK
GARFIELD
Cleveland Corners
Rodman Brook
Green River
Bruce Brook
Jones Brook
Wild Branch
CADYS FALLS INSET (3)
TOOTHAKER HILL 1380
LAMOILLE RIVER
TERRILL HILL 1200
LAKE LAMOILLE
Jacob Brook
Centerville Brook
Kenfield Brook
GRAND ARMY OF THE REPUBLIC HIGHWAY
FAP 34
FAP 15
FAS 80
FAS 10
SA
100
15
15A
MORRISTOWN
MORRISVILLE POP 2047 HD
MORRISVILLE-STOWE STATE AIRPORT
ST. JOHNSBURY
MONTPELIER-
LAMOILLE COUNTY RAILROAD
N
SOURCE OF MAP:
GENERAL HIGHWAY MAP
LAMOILLE CO., VT.
1965
DUFRESNE-HENRY ENGINEERING CORP.
ARCHITECT ENGINEER
U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS
LOCATION MAP
GREEN RIVER RESERVOIR
CLIENT NO. 04-0094
ENGR. MJR
SCALE 1"=1 MILE APPROX.
DATE MARCH 12, 1980

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
NAME OF DAM: GREEN RIVER RESERVOIR

SECTION 1 - PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Dufresne-Henry Engineering Corporation has been retained by the New England Division to inspect and report on selected dams in the State of Vermont. Authorization and notice to proceed were issued to Dufresne-Henry Engineering Corporation under a letter of November 20, 1978 from Max B. Scheider, Colonel, Corps of Engineers. Contract No. DACW33-79-C-0010 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by nonfederal interests.

(2) Encourage and prepare the states to initiate quickly effective dam safety programs for nonfederal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location

The Green River Reservoir Dam is located in north central Vermont, 44° 37.5' N latitude and 72° 32.0' W longitude, approximately 34 miles northeast of Burlington. The dam and most of the impoundment are located in the Town of Hyde Park, Vermont. A small portion of the impoundment to the north is located in the Town of Eden, Vermont. Vehicular access to the dam is on unimproved town roads originating in Morrisville, Vermont.

b. Description of Dam and Appurtenances

Green River Reservoir Dam is a concrete arch dam 97 feet high, 360 feet long, 23.6 feet thick at the bottom and 7 feet thick at the crest. The radius of curvature of the arch is 150 feet. A spillway section is located near the middle of the dam. The spillway section is 60 feet long and 5 feet high. A 5-1/2-foot diameter penstock with headgate releases water from the intake near the bottom of the dam. The 5-1/2-foot penstock is presently capped, and water is piped into the 2-1/2-foot bypass pipe where it is discharged into the stilling pool at the base of the dam. The headgate, the penstock and the outlet gate on the bypass are housed in separate valve houses located below the dam adjacent to the stilling pool. The stilling pool is created by a small concrete gravity dam approximately 180 feet downstream from the toe of the main dam.

An earthen dike is located approximately 1.4 miles to the southeast of the main dam at 44° 36.9' N latitude and 72° 30.5' W longitude. The dike is 248 feet long by 23 feet high and has an impervious core with cutoff trench.

c. Size Classification

The Green River Reservoir impounds 20,000 acre-feet of water to the top of the dam. The dam is 97 feet high. In accordance with the guidelines, dams with a storage volume of between 1,000 and 50,000 acre-feet and/or a maximum height of between 40 and 100 feet are classified as intermediate in size. Green River Reservoir Dam is therefore classified as intermediate in size.

d. Hazard Classification

If the Green River Reservoir Dam were to fail, a flood wave with 103,000 CFS and 50 feet high would be released. At the first impact site 8,000 feet downstream, the flood wave would be 45 feet high or 29 feet over the ground in the adjacent flood plain. This would completely destroy two homes and a trailer. There is little valley storage between the first impact site in the Village of Garfield and the next impact site 15,000 feet downstream which would involve a flood depth about 18 feet over Vermont Highway 15, or a total wave height 32 feet. This would destroy three more homes and move a significant amount of debris from a nearby auto salvage yard into the Lamoille River. The flood wave would continue down the Lamoille River 15 miles downstream. It would damage some property in the Village of Morrisville and flood some 28 structures in the Village of Johnson. Therefore, this dam has a high hazard classification.

Likewise, if the dike were to fail under normal conditions an initial discharge of 3,190 CFS would result. After traveling through the Zack Woods Pond and being routed through Perch

Pond a flow of 2800 CFS would remain. As the wave reached the confluence with the Wild Branch of the Lamoille River it would destroy one house located there. Therefore, the dike has a significant hazard classification.

e. Ownership

The Green River Reservoir Dam was constructed for and is owned by:

Village of Morrisville
Water and Light Department
Morrisville, Vermont 05661

f. Operator

The operation of the dam is supervised by:

Morrisville Water and Light Department
Mr. Robert Page, Superintendent
Morrisville, Vermont 05661

Telephone: 802-888-3348

g. Purpose

The primary purpose for which Green River Reservoir was constructed was to provide water storage to be used to generate power at several hydroelectric power stations along the Lamoille River. In addition, it was planned to construct a new hydroelectric generating plant at the dam. This plant was not constructed.

Additional purposes or benefits of the dam which were mentioned at the Vermont Public Service Board Commission hearings held November 14, 1945 include improvement of the recreation and scenic aspects of the area, flood control, maintenance of low water flows and improvement of employment opportunities in the region during the construction period.

Presently the dam serves to store water which is released in the winter to maintain flow to several downstream power generating stations.

h. Design and Construction History

Documentation of both the design and construction of the dam and dike are available, as well as a 1953 inspection report.

Design of the dam and dike was done by Charles T. Main Inc., Southeast Tower, Prudential Center, Boston, Massachusetts 02199. The design began in June 1944 and was completed in January 1946.

The Vermont Public Service Commission Hearing was held on November 14, 1945 and resulted in a finding of public good and authorization for construction.

Construction began in April 1946. By September of that year the dike was completed, much of the impoundment cleared and most of the rock excavation at the main dam completed. During October concrete pouring began. No concrete was poured during the winter of 1946-1947. Work began again in April 1947 and the dam was substantially completed by October 1947. "As-built" plans of the construction are available.

Information on the design and construction of the dam is contained in the Vermont Public Service Board, Case File #2295.

i. Normal Operating Procedures

Operating procedures for this dam consist of adjusting the flow from the reservoir via the headgate on the penstock. No other operating procedures are necessary. A more detailed description of the operation is contained in Section 4.

1.3 Pertinent Data

a. Drainage Area

The total drainage area for Green River Reservoir is 13.8 square miles of forested, unimproved, hilly land ranging in elevation from 1,854 at the top of McKinstry Hill to the reservoir which is normally at elevation 1,220 or below. The reservoir is so large that five streams with individual drainage areas of 4 square miles or less drain directly into the pond. The soils within the drainage area are well drained loamy soils with mostly shallow hardpan on bedrock.

b. Discharge at Dam Site

Flow may leave the reservoir either over the 60-foot long ogee spillway at elevation 1220 or through the 5-1/2-foot diameter penstock and 30-inch bypass regulated by a "Dow" valve.

(1) Outlet Works

5-1/2-foot diameter penstock to 30-inch bypass, invert elevation 1145.

(2) Maximum Known Flood at Dam Site

There are no records of flood flows after the construction of the dam. The highest flow recorded prior to the construction of the dam was 2,000 CFS for 18 square miles at U.S.G.S. gauging station No. 2910 operated in Garfield intermittently from 1915 to 1932.

(3) Ungated Spillway Capacity at Top of Dam

2,600 CFS at elevation 1225.

(4) Ungated Spillway Capacity at Test Flood Elevation

8,100 CFS at elevation 1230.5.

(5) Gated Spillway Capacity at Normal Pool Elevation

Not applicable.

(6) Gated Spillway Capacity at Test Flood Elevation

Not applicable.

(7) Total Spillway Capacity at Test Flood Elevation

8,100 CFS at elevation 1230.5

(8) Total Project Discharge at Test Flood Elevation

18,400 CFS at elevation 1230.5.

e. Elevation (feet above MSL)-DAM DIKE

(1) Streambed at Centerline

1,128. 1,207

(2) Maximum Tailwater

Not applicable. Not applicable.

(3) Upstream Portal Invert Diversion Tunnel

Not applicable. Not applicable.

(4) Recreation Pool

1,220

(5) Spillway Crest

	DAM	DIKE
(7) Design Surcharge (original design)	Not available.	Not available.
(8) Top of Dam	1,225	1,230
(9) Test Flood Surcharge	1230.5	1230.5

d. Reservoir

(1) Length of Maximum Pool

19,000 feet.

(2) Length of Recreation Pool

19,000 feet.

(3) Length of Flood Control Pool

Not applicable.

e. Storage (acre-feet)

(1) Recreation Pool

17,520 acre-feet.

(2) Flood Control Pool

Not applicable.

(3) Spillway Crest Pool

17,520 acre-feet.

(4) Top of Dam

20,360 acre-feet.

(5) Test Flood Pool

24,660 acre-feet.

f. Reservoir Surface (acres)

(1) Recreation Pool

620 acres.

(2) Flood Control Pool

Not applicable.

(3) Spillway Crest

620 acres.

(4) Test Flood Pool

700 acres.

(5) Top of Dam

680 acres.

g. Dam	Dike
(1) Type	
Concrete arch.	Earth embankment.
(2) Length	
360 feet.	248 feet.
(3) Height	
97 feet.	23 feet.
(4) Top Width	
7 feet.	20 feet
(5) Side Slopes	
Not applicable.	Upstream - 1 on 3 Downstream - 1 on 2.5
(6) Zoning	
Not applicable.	Not applicable.
(7) Impervious Core	
Not applicable.	The impervious earth core runs from a top elevation of 1228 where it is 6 feet wide to the ground elevation of 1207 where it is 20 feet wide.

	Dam	Dike
(8) Cutoff	Base is keyed into unweathered rock.	The impervious core continued below original ground to a hardpan foundation layer, approximate elevation 1200.
(9) Grout Curtain	Varies, 12-24 feet below concrete foundation.	Not applicable.

h. Diversion and Regulating Tunnel

Not applicable.

i. Spillway - At Dam		At Dike
(1)	Type	
	Ogee weir.	Not applicable.
(2)	Length of Weir	
	60 feet.	Not applicable.
(3)	Crest Elevation	
	1,220.	Not applicable.
(4)	Gates	
	None.	Not applicable.
(5)	Upstream Channel	
	Reservoir.	Not applicable.
(6)	Downstream Channel	
	Plunge/stilling pool.	Not applicable.

j. Regulating Outlets

Dam: A 5-1/2-foot diameter conduit penetrates the base of the dam. There is a box intake, grated, at the upstream face of the dam which is the intake for the conduit. On the downstream face of the dam is an intake valve house in which the conduit terminates. Flow in the 5-1/2-foot conduit is controlled by a 6-foot diameter "Dow" valve located in the intake valve house.

Downstream of the valve is a "Y" connection into a 30-inch discharge conduit. This conduit travels underground to the outlet valve house where it is valved by a 30-inch "Dow" valve. The 30-inch conduit then discharges into the stilling basin. The 5-1/2-foot leg of the V-connection was originally designed to act as a penstock to accommodate power generating equipment. However, no such facilities were ever incorporated. Thus the 5-1/2-foot leg of the connection remains capped. The outlet discharge capacity is about 370 CFS.

SECTION 2 - ENGINEERING DATA

2.1 Design

Design computations were not readily available. "As-built" drawings and construction records were kept during the construction of the dam. This information is available at the office of Charles T. Main Inc., Southeast Tower, Prudential Center, Boston, Massachusetts, and contained, in part, in Appendix B.

2.2 Construction

Construction on the dam and dike began in the spring of 1946. The dike was completed in September of 1946 and the dam was finished in October of 1947. The contractor was O. W. Miller and Company. Records indicate that the materials and methods of installation were monitored by the engineer, the owner and the Vermont Public Service Commission. Construction records are available from Charles T. Main Inc. and from file #2295 of the Vermont Public Service Board.

2.3 Operation

Operation of the dam is minimal, consisting only of adjusting the headgate to control discharge. The operation is performed by the Morrisville Water and Light Department.

2.4 Evaluation

a. Availability

"As-built" plans, design and construction data are available as noted in 2.1 and 2.2 above.

b. Adequacy

Sufficient data are available for a Phase I inspection.

c. Validity

The available engineering data are considered valid on the basis of the visual inspection.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. General

The on-site inspection of Green River Reservoir Dam was conducted on April 30, 1979. On the day of the inspection the water level in the reservoir was 12.5 feet below the crest of the dam. Both the dam and dike were found to be in good condition. No emergency conditions were noted during the inspection.

b. Dam

Green River Reservoir Dam is a medium sized concrete arch dam. The inspection of the dam was begun on the left abutment and ended on the right abutment. In most areas the concrete appeared in good condition, with minor spalling and efflorescence visible randomly on the crest and downstream face of the dam (refer to photographs 1, 2 and 4). The first section of the crest, left abutment, evidenced general surface spalling (see photo 8).

There was evidence of the base plates for fence gates on both the left and right ends of the dam crest. The gates have apparently been removed and the lock damaged on the gatehouse door. There was a ladder on the upstream face of the dam which provided access to the intake when the reservoir was drawn down. This ladder has been extensively damaged by ice and is, for all intents and purposes, not usable.

The concrete on the spillway control section appears in excellent condition with only one minor area of spalling to the right of the center construction joint. A few small holes were observed on the downstream face. As seen in Photo 20, a small clear flow of water was coming from one of these areas approximately 60 feet from the left abutment contact.

Minor seeps occur in general all along the right abutment interface, but no signs of structural impairment were evident. At approximately half-way down the right abutment clear water was flowing from a joint in the rock approximately 20 feet downstream of the dam, but flow was not excessive (see Photo 19). There was only a small wet area with no observable flow on the downstream side of the left abutment.

The plans and specifications indicate a grout curtain was to be formed by drilling and grouting the rock under pressure. Some evidence of these grout holes remain on the downstream side of the right abutment.

A natural rock channel forms the downstream discharge for the dam. Photo 10 illustrates this channel and shows the weir constructed to form a stilling basin below the spillway. The 79-foot long by 18-foot high gravity concrete weir is in good condition with only minor spalling on the discharge face.

The dike comprises a rolled earth fill structure with an impervious core built from select impervious borrow material. Both upstream and downstream slopes are protected with stone riprap. There is no spillway in the dike. Photo 11 illustrates the general appearance of the dike; Photo 13 shows the upstream face and Photo 14 shows the downstream face. Photo 15 illustrates the terrain below the dike. Due to the low reservoir water level, no evaluation could be made of seepage through the dike, which was alluded to in the operating records. As can be seen from the photographs, the dike itself appears in good condition, even though some brush and small trees have been allowed to grow on the slopes.

Construction plans and specifications indicate an upstream slope of 3 to 1 and a downstream slope of 2.5 to 1 with a crest width of 20 feet. The specifications required installation of a filtered underdrain below the upstream portion of the dike, but this is not shown on the plans provided.

c. Appurtenant Structures

The outlet valve house (see Photos 5 and 6) appears in good structural condition. Some leakage from the valves was evident, as illustrated in Photo 23. The outlet conduit was flowing full so it could not be inspected.

Immediately downstream from the Green River Reservoir Dam is a stilling basin with a concrete dam and spillway, as shown in Photographs 1 and 10. The stilling basin is formed from the natural channel and the concrete dam spanning its width. Both the basin and gravity dam are in good condition.

d. Reservoir Area

The reservoir area consists of approximately 720 acres and serves to provide water storage for several power generating stations located along the Lamoille River. The banks of the impoundment area are well forested and there are no signs of erosion, sloughing or slope instability.

e. Downstream Channel

The downstream channel, as shown in Photograph 10, is a natural channel formed from rock. It is in good condition with only a few trees overhanging into it.

3.2 Evaluation

Seepage, spalling and efflorescence at the main dam appear minimal and do not appear to impair the safety of the dam. Access to the intake structure is needed before an inspection can be performed within the structure itself. Inspection of the outlet structure revealed a valve stem gland that needed repacking to stop the existing leaking condition. The dike could not be evaluated fully due to insufficient head. The visual inspection did not disclose any obvious problems with the dike, but a complete assessment should await additional inspection at a time of high reservoir level.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

The established operational procedures for Green River Reservoir are for flow augmentation releases to downstream hydroelectric plants. The water level is maintained 35 feet below the spillway crest during the winter and then brought up to within 3 feet of the spillway during spring runoff. Morrisville Water and Light Department operates gate valves under the direction of Central Vermont Public Service Corporation's power needs.

4.2 Maintenance of Dam and Dikes

The existing maintenance of the dam consists of weekly inspections and repairs as required, including general clean-up and removal of debris. Brush on the dike embankment is cut every year or so.

4.3 Maintenance of Operating Facilities

The machinery and valves are maintained in good operating condition.

4.4 Description of Warning System in Effect

None exists for this dam.

4.5 Evaluation

The operation and maintenance of the Green River Reservoir are barely adequate to maintain a safe and workable facility due to the difficulty of accessing the intake structure and the neglect in replacing the fence and gates at the dam abutments and maintaining security at the gatehouse.

SECTION 5 - HYDRAULIC/HYDROLOGIC EVALUATION

5.1 Evaluation of Features

a. General

The Green River Reservoir is a high surcharge storage - low spillage type dam. The concrete arch dam is 97 feet high and 360 feet long with an ogee spillway 60 feet long and 5 feet deep in the center of the dam (see Photo 1). A dike located 1.4 miles southeast of the dam is an earth embankment with impervious core. This reservoir was built as a storage project for flow augmentation to downstream hydroelectric projects. It is also used for recreation with wilderness camping, fishing and swimming permitted around the reservoir.

b. Design Data

There is no readily available design data.

c. Experience Data

The maximum observed water level at Green River Dam has occurred during the early season snowmelt runoff with 5 inches of water measured over the spillway (elevation 1220.4). Prior to the construction of the dam, the November 1927 flood had a flow of 2,000 CFS at the site of U.S.G.S. gauging station number 2910 at Garfield which operated intermittently from 1915 - 1932.

d. Visual Observation

The visual inspection of the dam revealed some spalling of the concrete on the dam crest near the left abutment and a few rat holes on the face of the dam. The 60-foot long ogee weir which serves as the spillway was in good condition with no debris in evidence. The stilling pool below the dam has retained some debris and the weir controlling the pool has sustained a small amount of spalling on the downstream face.

The control valve on the 5-1/2-foot diameter penstock has a leak at the packing gland on the operating stem. The bypass valve could not be inspected because the lock on that valve house door was damaged.

e. Test Flood Analysis

The Green River Reservoir Dam is classified to be an intermediate size dam with a high hazard rating; therefore a Probable Maximum Flood (PMF) was selected as the test flood. The computations

of the test flood were carried out by breaking the drainage basin into six subareas and using a computer program, HEC-1, and flood routing the test flood through the reservoir. The input data computations and results are contained in Appendix D of this report. The relatively large reservoir area offers significant flood regulation for the 14 square mile drainage area and therefore the test flood inflow of 36,300 CFS (2,623 CSM) produced a routed test flood outflow of 18,400 CFS. Since the existing spillway capacity of 2,600 CFS is only 12 percent of the test flood, the dam would be overtopped by 5.5 feet at a test flood elevation of 1230.5. The resulting overflow would erode trees and possibly damage the valve houses. Meanwhile, during the routed test flood outflow the dike would be overtopped by 0.5 feet.

f. (1) Dam Failure Analysis

If Green River Reservoir Dam were to fail with the water level at the top of the dam, a flood wave with 103,000 CFS and 50 feet high would be released compared to the spillway capacity of 2,600 CFS which is equivalent to the Flood of Record. Due to the dam height, greater than 90 feet, there would be little difference in the impact of the dam failing with the reservoir at the spillway crest or the top of the dam. Hence there could be a sudden increase in river levels from normal stages to the dam break flood wave.

The flood wave would travel 8,000 feet to the first impact site. The flood wave at this point would be 97,500 CFS and approximately 45 feet high. This would completely destroy two homes and a trailer (see Photo 16). There is little valley storage in the next 15,000 feet to the second impact site. A flood wave approximately 18 feet over Vermont Highway 15, or a total wave height of 32 feet would destroy three more homes and move a significant amount of debris from a nearby auto salvage yard into the Lamoille River. The flood wave would then continue down the Lamoille River to the Village of Morrisville.

At Morrisville it would pass over 2 dams. At the upper dam the water would be 14 feet high and flowing at the rate of 66,600 CFS which is 80% greater than the Flood of Record, November 1927. At the lower dam the stage would be 18 feet and the flow 51,500 CFS. This flood wave would be 4 feet higher than the 1927 Flood at this point.

The next impact point would be the Village of Johnson. The depth of flooding is estimated to be between 6-15 feet over the ground in the Village area. Twenty-eight buildings, many of them residences, are likely to be affected. The peak flow is estimated to be 28,000 CFS when it passes through Ithiel Falls Gorge.

The valley storage below Ithiel Falls would gradually diminish the flood wave so that it would be contained in the channel by the time it reaches Cambridge Junction.

(2) Dike Failure Analysis

If the dike at the Green River Reservoir were to fail under normal conditions an initial flow of 3190 CFS would result acting in a wave approximately 7 feet deep. This water would pass through Zack Woods Pond into Perch Pond, which after routing would result in a flow of 2800 CFS. From Perch Pond the wave would enter the Baldin Brook and continue down this brook until it reached the confluence with the Wild Branch of the Lamoille River. Here a single house would be endangered by a wave approximately 7 feet deep. After entering the Wild Branch of the Lamoille River the flood wave would represent a 10-year flood. However, due to the volume of water available in the reservoir the breach can widen before the water level will drop significantly. The flow down Baldin Brook would increase to 5200 CFS which is comparable to a 100-year flood on the Wild Branch of the Lamoille River. Either flood wave would be on the order of 8 feet deep and 300 feet wide on the Wild Branch based on data available from an ongoing Flood Insurance Study for the Town of Wolcott, Lamoille County, Vermont.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The visual inspection did not disclose any immediate stability problems in either the dike or the dam.

b. Design and Construction Data

The available data indicates a very stable configuration of the earth dike in terms of its width to height ratio. The design and construction data available are not sufficient for a formal stability analysis of the concrete arch dam.

c. Operating Records

The operating records contain no indication of dam instability, but they do contain reference to excessive seepage through the dike at times of high water (1953 dam inspection).

d. Post-Construction Changes

The available data does not refer to any known post-construction changes in the dam or the dike.

e. Seismic Stability

The dam is located in Seismic Zone 2 and in accordance with the recommended Phase I guidelines does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/ REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition

Based on the visual inspection and a review of the available data, the dam, overall, is in good condition but is judged to be fair due to overtopping potential.

The low reservoir level precluded complete assessment of the condition of the dike. However, the dike is judged to be in fair condition due to the observations in previous inspection report of a large seep.

b. Adequacy of Information

The information available was sufficient for a Phase I Inspection, but not for a complete analysis of dam stability. Visual inspection substantiates that the available information is indicative of actual conditions.

c. Urgency

The recommendations given in Section 7.2 and 7.3 should be carried out within one year after receipt of this report.

d. Need for Additional Investigations

The dike should be inspected during the next time of high water.

7.2 Recommendations

The following actions should be taken under the guidance of a registered professional engineer qualified in the design of dams.

1. An inspection of the dike should be performed at high reservoir levels so that any seepage can be assessed and monitored.

2. The seepage at the right abutment of the concrete arch dam should be monitored and recorded.

3. Prepare a detailed hydrologic and hydraulic analysis of the spillway capacity and evaluate the ability of the dam to withstand overtopping.

7.3 Remedial Measures

a. Operation and Maintenance Procedures

The following items are recommended:

1. A program of biennial safety technical inspections should be instituted.

2. A formal warning plan should be prepared and round-the-clock surveillance should be provided during periods of unusually heavy precipitation or high project discharges.

3. The small trees and brush growing on the dike faces should be cut. This area has been cut before and should be kept free of such growth in the future.

4. To make the dam and valve houses safe from trespassers, the gates at the abutment crest should be replaced and steel covers attached over valve house locks to prevent them from being damaged.

5. The spalling areas and holes on the dam and stilling basin weir should be cleaned and repaired to prevent further deterioration.

6. The packing gland on the operating stem of the "Dow" valve on the penstock should be serviced to prevent that condition from becoming worse and possible deterioration to the interior of the valve house.

7.4 Alternatives

Not applicable.

APPENDIX A

VISUAL INSPECTION CHECK LIST

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT GREEN RIVER RESERVOIR

DATE April 30, 1979

TIME 10:30 AM - 2:15 PM

WEATHER Warm, partly cloudy

W.S. ELEV. 1212.5 U.S. DN.S.

PARTY:

1. Walter A. Henry D-H
2. John R. Spencer D-H
3. Sherward G. Farnsworth D-H
4. Gonzalo Castro GEI
5. Rodger Gardner GEI
6. Peter Barranco, Vt. Water Resources Board
7. William Pickens, Morrisville Water & Power Company
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

PERIODIC INSPECTION CHECK LIST

PROJECT GREEN RIVER RESERVOIR DATE April 30, 1979

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
DAM, CONCRETE ARCH	
Crest Elevation	1220.0 feet.
Current Pool Elevation	1212.5 feet.
Maximum Impoundment to Date	17,800 acre-feet.
Surface Cracks	Construction joints.
Concrete Condition	Efflorescence, minor spalling.
Movement or Settlement of Crest	None observed.
Lateral Movement	None observed.
Vertical Alignment	Good.
Horizontal Alignment	Good.
Condition at Abutment and at Concrete Structures	Good.
Indications of Movement of Structural Items on Slopes	Not applicable.
Trespassing on Slopes	Not applicable.
Sloughing or Erosion of Slopes or Abutments	Not applicable.
Rock Slope Protection - Riprap Failures	Not applicable.
Unusual Movement or Cracking at or Near Toe	Not applicable.
Embankment or Downstream Seepage	Seepage at right abutment, 24 feet from west and below. Through base of dam and through rock downstream.
Piping or Boils	None observed.
Foundation Drainage Features	None known.
Toe Drains	None known.
Instrumentation System	None known.
Vegetation	Not applicable.

PERIODIC INSPECTION CHECK LIST

PROJECT GREEN RIVER RESERVOIR DATE April 30, 1979

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation	
Current Pool Elevation	
Maximum Impoundment to Date	
Surface Cracks	None evident.
Pavement Condition	Not applicable
Movement or Settlement of Crest	None evident.
Lateral Movement	None evident.
Vertical Alignment	Good.
Horizontal Alignment	Good
Condition at Abutment	Good.
Indications of Movement or Structural Items on Slopes	Not applicable.
Trespassing on Slopes	No damage caused.
Sloughing or Erosion of Slopes or Abutments	None evident.
Rock Slope Protection - Riprap Failures	Riprap, good condition, at both upstream and downstream slopes.
Unusual Movement or Cracking at or Near Toe	Toe covered with snow.
Unusual Embankment or Downstream Seepage	Toe covered with snow.
Piping or Boils	Toe covered with snow.
Foundation Drainage Features	Filter drain mentioned in spec but not shown on sketch.
Toe Drains	Toe covered with snow.
Instrumentation System	None evident.
Vegetation	Grass and small bushes, one inch stock at a few locations.

PERIODIC INSPECTION CHECK LIST

PROJECT GREEN RIVER RESERVOIR DATE April 30, 1979

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE STRUCTURE	
a. Approach Channel	None observed.
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	Not observable, under water.
Condition of Concrete	
Stop Logs and Slots	

PERIODIC INSPECTION CHECK LIST

PROJECT GREEN RIVER RESERVOIR DATE April 30, 1979

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	Not applicable.
a. Concrete and Structural	
General Condition	
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System	

PERIODIC INSPECTION CHECK LIST

PROJECT GREEN RIVER RESERVOIR DATE April 30, 1979

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION AND CONDUIT	Not applicable
General Condition of Concrete	
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECK LIST

PROJECT GREEN RIVER RESERVOIR DATE April 30, 1979

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	Good.
Rust or Staining	Minimal.
Spalling	None observed.
Erosion or Cavitation	None observed.
Visible Reinforcing	None observed.
Any Seepage or Efflorescence	Minimal efflorescence at left upstream corner.
Condition at Joints	Good.
Drain Holes	At right wall (retaining wall).
Channel	Natural streambed, with stilling basin controlled by downstream weir located 180 feet downstream of spillway.
Loose Rock or Trees Overhanging Channel	Some trees.
Condition of Discharge Channel	Good.

PERIODIC INSPECTION CHECK LIST

PROJECT GREEN RIVER RESERVOIR DATE April 30, 1979

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - EMERGENCY SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	None observed.
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir	
General Condition of Concrete	Good.
Rust or Staining	None observed.
Spalling	Minimal at downstream edge of weir.
Any Visible Reinforcing	None observed.
Any Seepage or Efflorescence	None observed.
Drain Holes	Not applicable.
c. Discharge Channel	Natural stream, see outlet channel.
General Condition	Excellent.
Loose Rock Overhanging Channel	None.
Trees Overhanging Channel	None.
Floor of Channel	Natural streambed.
Other Obstructions	None

PERIODIC INSPECTION CHECK LIST

PROJECT GREEN RIVER RESERVOIR DATE April 30, 1979

PROJECT FEATURE NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	Not applicable.
a. Super Structure	
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Underside of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

PERIODIC INSPECTION CHECK LIST

PROJECT GREEN RIVER RESERVOIR DATE April 30, 1979

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
RESERVOIR AREA	
Stability of Shoreline	Good, close to dam.
Sedimentation	None observed.
Changes in Watershed Runoff Potential	None known.
Upstream Hazards	None known.
Downstream Hazards	Homes both downstream of dam and dike.
Alert Facilities	None.
Hydrometeorological Gages	None.
Operational & Maintenance Regulations	Routine inspection by Morrisville Water and Power Company.

APPENDIX B

PROJECT RECORDS AND PLANS

CONTENTS

- GREEN RIVER DAM -

LOCATION:	Town of Eden and Hyde Park, Vermont
AREA:	625 acres
CAPACITY:	758 million cubic feet
USE:	Storage for Lamoille River Hydro Stations
ELEVATIONS:	Base of dam 1,115 ft. Brook 1,135 ft. Spillway 1,220 ft. Top of dam 1,225 ft.
LENGTH:	320 ft.
DRAINAGE AREA:	14 square miles
MAXIMUM DISCHARGE UNDER FULL HEAD:	373 C.F.S.
TIME DISCHARGE FULL POND THROUGH GATE:	44 days
DIAMETER:	Main gate 72" Discharge gate 30"
THICKNESS:	At base 40 ft. At top 7 ft.
CUBIC CONTENT:	10,300 yards
WEIR:	Length 79 ft. Height 5 ft.
DIKE:	Length 248 ft. Height 20 ft. Thickness at base 150 ft. Thickness at top 20 ft. Elevation at top 1,230 ft.

PONDS FLOODED BY NEW LAKE:

Great	Pond
Clear	"
Dead	"
Long	"
Round	"
Hyde	"
Half Round	"

DATE OF CONSTRUCTION: 1946-47

INSPECTION REPORT
ON
Green River Dam

1. Date of inspection May 4, 1953 2. Water conditions Pond level 10 below crest.

GENERAL DATA:

3. Location of dam Green River, town of Hyde Park.

4. Owner and operator Village of Morrisville

5. Characteristic features of dam Concrete arch dam 100 ft. high (main section); earth dike 20 ft. high.

6. Other related data (For details see writer's report of May 3, 1951 and PSC case file #2295)

OBSERVATIONS:

7. Condition of structure Concrete section - observed leakage of joints in two locations, some amount of leakage at abutmen condition not seriously affecting structure.
Dike - Seepage continues as observed previously, no change in stability of section.

8. Condition of equipment Satisfactory

9. Operation Satisfactory

10. Maintenance Satisfactory

REMARKS:
Dam remains in an acceptable condition.

Inspected by Stephen N. Hayford

passed on the work. His report, contained in the case file, indicates that the structures were appropriately designed and constructed.

Brief description of appurtenances

Both the dam and the dike of this development are detailed in the case file by drawings, photographs and reports. Briefly, these appurtenances are as follows:

The dam - is a concrete arch structure on a ledge rock foundation in the main river valley. Curved in plan to a 150 ft. radius it has a running length of about 350 ft. and a maximum depth of about 100 ft. It has a top width of 7 ft. and a base width (at maximum section) of 23.6 ft. Centered in the river channel is a shaped overflow notch, 60 ft. long and 5 ft. deep. A small concrete weir below the dam provides a stilling pool for falling water. To the east of the spillway is an intake structure and valve house for low level control of discharge.

The dike - is an earth embankment closing the rim of the reservoir at its south easterly end. It is about 180 ft. long and 23 ft. high. Its top width is 20 ft. with the upstream face sloping 1 on 3 and the downstream face 1 on 2.5. Both faces are covered with 18" of stone riprap. A core of impervious material is keyed into the earth foundation.

Observations at the dam

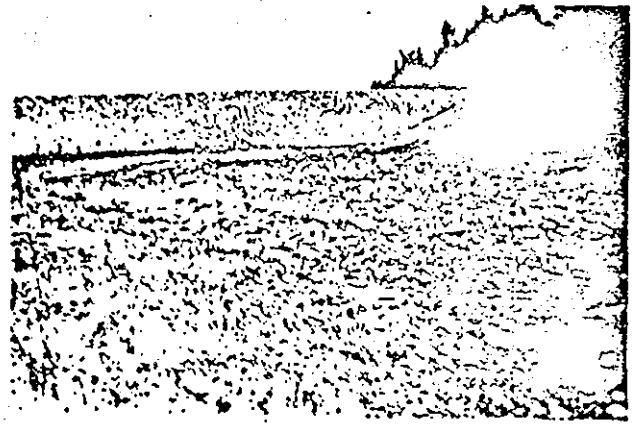
A full pond is well contained by the dam. Sweating joints were noted in two locations; also, some leakage through the rock end abutments. However, these had little significance.

Localized spalling of the concrete surface at a point near the base just west of the spillway was observed. This too is minor. The concrete dam, in general, still shows an excellent finish. It is further preserved by a coating of a bituminous material on its upstream face.

A stilling pool at the base lessens the possibility of scour from flood discharges over the spillway.

Observations at the dike

Unlike the situation at the dam site, a full pond level or any pond level in the upper reaches has an adverse effect at the dike site. The reservoir rim at this point, consisting of a glacial deposit, proved to be not as tight as anticipated. Seepage emerges from this material just below the dike, the bulk appearing in the area shown in the photograph below. With the higher pond levels, water-filled depressions and other ponds in the vicinity fluctuate accordingly.



The seepage is estimated to be at least 10 c.f.s. For the present, the owner has excavated a channel to drain this escaping water into Zack Woods Pond and eventually the Lamoille River.

The dike itself appears to be tight and stable. Ample freeboard is provided to secure it against overtopping. Under existing conditions, its safety depends on the stability of the foundation.

Conclusions

From these observations of full pond level conditions at the Green River storage development, it may be concluded that:

(1) Behavior at the dam is within limits of the design;

(2) Seepage is appreciable at the dike but is not, at present, an unstable condition since no piping (transportation of foundation material) is apparent. However, this defect should be closely watched. It may require extensive remedial measures or it may eventually seal itself.

STEPHEN H. HAYBROOK
HYDRAULIC ENGINEER

Public Service Commission

Report No. 204

May 3, 1951

Green River Project

Statement by H. K. Barrows

Green River Project

The proposed Green River Project includes an 100 foot arched concrete dam located upon Green River in the Town of Hyde Park, about four miles from the entrance of the stream to the Lamoille River. The dam will form a storage reservoir for power use at hydro plants of the Town of Morrisville municipal power system and those of the Public Electric Light Co. system - all upon Lamoille River.

Dam The proposed Green River dam located in a narrow gorge will be 100 feet in maximum height of concrete masonry and curved in plan with a radius of 150 feet to the upstream face. Its foundations will be on solid ledge rock of good quality. It will include the following:-

(1) An abutment section upon the left (easterly) bank about 205 feet long (on the curve) with a height varying from about 10 to 100 feet - top at El. 1225.

(2) A spillway section approximately in the middle of the dam, 60 feet long (on the curve) and about 100 feet in height - crest at El. 1220.

(3) An abutment section upon the right (westerly) bank about 145 feet long (on the curve) with a height varying from about 30 to 100 feet; top at El. 1225.

(4) A 5 1/2 feet pipe at El. 1148 will pass through the easterly abutment section near the spillway to be used as a penstock for a future power house, just below the dam. From this pipe a 2 1/2 ft. bypass pipe will branch to serve for reservoir discharge prior to the time the power house is built.

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(3) An abutment section upon the right (westerly) bank about 145 feet long (on the curve) with a height varying from about 10 to 100 feet; top at El. 1225.

(4) A 5 1/2 foot pipe C/o El. 1148 will run through the easterly abutment section near the spillway to be used as a penstock for a future power house, just below the dam. From this pipe a 2 1/2 ft. bypass pipe will branch to serve for reservoir discharge prior to the time the power house is built.

(5) A stilling pool with concrete apron will be built below the spillway to receive any discharge over it or from the bypass pipe.

The total length of dam will be about 400 feet; it will be 7 feet thick at the top and about 23.6 feet at the base.

A study of this section indicates that it is designed for a concrete masonry compressive arch stress of 40,000 lbs. per sq. foot throughout its height which is in the writer's judgment satisfactory and safe. Arch dams of this type and design are very dependable and never have failed structurally, as far as known.

Dike At the divide near the south easterly end of the reservoir a dike is required to prevent water overflowing from the drainage area. This will be of earth 20 feet wide on top at El 1230, with side slopes of 1 on 3 for the reservoir side and 1 on 2 1/2 for the land side. This dike will be 23 feet in maximum height above ground level, and have an earth core of impervious material with maximum section 6 feet wide at top, El 1228 and 20 feet wide at ground level, and 2 feet wide at the hard pan foundation at about El. 1200, and will be about 180 feet long.

Storage Reservoir Drainage area at the dam is about 14 sq. miles. The area of the reservoir formed by Green River dam will be about 625 acres at spillway level El. 1220 and storage capacity between El. 1220 and 1150 will be about 760 million cubic feet or about 17000 acre feet. This is the equivalent of about 1210 acre feet per sq. mile of drainage area or a depth

upon that area of about 23 inches or approximately a year's average run off. This is a very high degree of storage and little, if any, water will need to be wasted in operating the reservoir.

The reservoir area is mostly wood land with small timber - no farming units or meadow land. It includes several ponds and some bog land. Land owned by the Town of Morrisville is shown on Ex. No. 3 and includes an area much larger than that of the reservoir - about 3/4 in the town of Hyde Park and the remainder in the Town of Eden. There are six or seven abandoned farms and no new roads will be required due to the reservoir as only wood roads are now in this area.

Effect of Storage The hydro plants and developed heads upon Lamoille River below the proposed reservoir are as follows:

Plant	Owner	Head Feet
Morrisville	Town of Morrisville	37
Cady's Falls	do	46
Fairfax Falls	Public El. Lt. Co.	60
Clark's Falls	do	41
Milton	do	95
Woods Falls (proposed)	do	50
Total		349

The proposed future hydro plant at the Green River reservoir will be of 1000 K.w. capapcity under a head of 65 feet, bringing the total head up to 414 feet.

It is planned to eventually construct a high head hydro plant on Green River to utilize the head between the reservoir and Lamoille River. The total available fall is about 560 feet mostly in the 2.2 mile stretch to Garfield. Including this there will eventually be about 860 feet of head through which the water from the reservoir will be used.

Flood Capacity of Dam Based upon experience in the 1927 flood a maximum flow of 300 c.f.s. per sq. mile may occur on Green River or 4200 c.f.s. for the 14 sq. miles of drainage area. This would be a flood with about 8 inches run off or only about 1/3 the reservoir capacity, and would probably always be absorbed by the reservoir.

However assuming a full reservoir at the beginning of such a flood there would be sufficient storage capacity above spillway level to reduce the peak flood flow from 4200 c.f.s. to about 2100 c.f.s. The capacity of the 60 foot spillway is about 2600 c.f.s. so that it is entirely adequate to handle any possible flood which may occur.

Town of Morrisville - Power Requirements. The Morrisville Power system supplies eastern Lamoille County, the Village of Stowe, Eastern Magnesia Talc Co. in Johnson, and in part to Hyde Park, Johnson and Wolcott.

The two hydro plants - Morrisville and Cady's Falls - have a total capacity of 2400 K.w. but only about 700 K.w. of firm power during the low water season, and power has to be purchased from the West Danville plant of the Green Mountain Power Corporation. This fails at times due to an overloaded line.

Ex. No. 11 shows that power requirements have increased from 3 million K.w. Hrs. yearly in 1925 to 7.5 million K.w. Hrs. in 1945 and a greater rate of increase is likely in the next 5 years due to increasing farm and domestic use of power.

The increase in firm power from the hydro plants due to the proposed reservoir will be about 1 million K.w. hrs. yearly. The steps proposed to meet power requirements include:

(1) Install a Diesel unit at Cady's Falls for immediate help

(2) Green River Reservoir

(3) Power plant at base of reservoir dam

(4) High head plant at Lamoille River

Cooperation with Public Electric Light Co. - stored reservoir water will be used at the four hydro plants of the Public Electric Light Co. on Lamoille River, which is cooperating with the Village of Morrisville in the developing and use of Green River reservoir. The power demands of this company include the City of Burlington, Town of Swanton, 850 farms and 4000 domestic customers and are now increasing about 10% each year.

As Mr. Peterson, their General Manager, stated: "By cooperation with Morrisville water from Green River can be utilized and turned into good power for the people of this northern section."

Cost The estimated cost of Green River reservoir is $350,000. including dam, dike and clearing.

The cost of hydro power is about 0.6 cent per K.w. Hr. as compared to purchased power at 2 1/4¢ per K.w. Hr.

In General No tillable farm land is flowed by the proposed reservoir. It will improve facilities for boating and fishing as well as scenic aspects. It is a true conservation measure and will help to maintain the low water flow and increase the available firm power at hydro plants upon Lamoille River below, and lessen flood tendencies.

It will increase taxable values and provide employment in Hyde Park and Eden while under construction.

Structures In the judgment of the writer the Green River dam and reservoir and their appurtenant features, as shown upon the preliminary plans filed with the Commission, provide adequately for the public safety, and their approval is recommended subject to their incorporation and review in the finished plans of the project, and the use of the finished plans in construction.

Green River Project will, in the judgment of the writer, serve the public good, defined as that which shall be for the greatest benefit of the people of the State of Vermont.

SPECIFICATIONS
For
CONSTRUCTION WORK AND MATERIALS
For The
GREEN RIVER STORAGE DAM & DIKE
For The
VILLAGE OF MORRISVILLE
WATER AND LIGHT DEPARTMENT
MORRISVILLE, VERMONT

CHAS. T. MAIN, INC.
ARCHITECT - ENGINEERS
201 DEVONSHIRE ST.
BOSTON 10, MASS.

October 15, 1945

I. GENERAL

(a) Purpose:

These specifications and accompanying documents, including the drawings are intended to cover the construction of the Green River Storage Dam and Dike for the Water and Light Department of the Village of Morrisville, Vermont.

The Contractor shall do all of the work indicated in these specifications and on the plans and such additional work as may be necessary to complete the dam and appurtenances in a substantial and acceptable manner and leave the work in a neat and finished condition.

(b) Description:

The storage dam will be constructed across the Green River about 4 miles from its confluence with the Lamoille River. It is to be located in the gorge about 1.3 miles upstream from the Garfield Bridge.

The site of the dam is in the township of Hyde Park and is about 5 miles from the Morrisville railroad station.

Improved roads lead from Morrisville to the Garfield Bridge, part being hard surface and part being gravel roads.

From the Garfield Bridge there is an old town road of one lane width leading up the valley passing the gorge about one half mile to the east.

An old logging road, which has recently been improved to provide access to the site, runs from the old town road to the top of the gorge at the damsite.

The Contractor would be expected to do such work on this road to make it suitable for a construction road.

The average flow over a 15 year period was about 27 c.f.s. with a maximum recorded flow of about 110 c.f.s. The Contractor would be expected to construct and maintain the necessary coffer dam and waterways to protect his construction work.

The dam is to be a concrete arch type with a maximum height of about 100 feet, about 24 feet thick at the base and 7 feet thick at the top.

The approximate length of the dam, at the top, measured on the arc is about 410 feet.

There is to be a headgate with racks and a steel penstock through the dam to serve a future power plant to be constructed just downstream from the dam.

This penstock is to be blocked off for future connection to the turbine.

A bypass pipe 30" dia. is to be taken off from the side of this penstock to permit water at present to be drawn from the storage reservoir for use in the plants downstream and for the future bypassing of water around the turbine. A 30" dia. electrically operated Dow valve is to be installed near the downstream end of the bypass pipe. This pipe is to discharge into a pool downstream from the dam.

The pool is to be formed by a small gravity dam about 40 feet downstream from the toe of the storage dam.

The dike is to be of earth with a top width of 20 feet and a length on top of about 200 feet.

The maximum height above the present surface is about 20 feet. The core will be carried to impervious material about 11 feet below the present surface. The core will be constructed of impervious material. The embankment outside of the core will be of compacted glacial till and both slopes will be riprapped to prevent erosion. The dike is located about 1-1/2 miles in a southeasterly direction from the dam location, and near the road from Garfield to Craftsbury.

II. DRAWINGS

The following general drawings are a part of these specifications and contract.

Drawing No.	Title

These drawings show the approximate dimensions and shape of the dam and related structures and the general arrangement of all features.

Such additional drawings as may be required for the details of the work will be furnished to the Contractor as required. The Contractor will not be held responsible for the correctness or sufficiency of the designs, but the Contractor shall keep a careful check upon dimensions and details as the work progresses, and any errors or discrepancies discovered shall be promptly reported to the Engineers.

The Contractor will be furnished such additional copies of the drawings and specifications as may be required for carrying out the work, not to exceed 6 sets. Additional sets may be secured at cost.

III. LINES, GRADES & LOCATIONS

(a) The Engineer will give such lines, grades, and measurements as may be necessary to the proper prosecution of the work and the Contractor shall keep the Engineer informed, a reasonable time in advance, of the time and places at which he intends to do work, in order that lines and grades may be given and necessary measurements for record and payment may be taken with a minimum of inconvenience to the Engineer, or of delay to the Contractor; and the Contractor shall have no claims for damages or extensions of time on account of delays in the giving of lines and grades, or destruction of such marks and the consequent necessity for replacement.

Whenever the Engineer finds it necessary to carry on his operations at times when the work of the Contractor is not in progress, the Contractor shall furnish all necessary services and assistance. No direct compensation shall be made for the cost to the Contractor for any work or delay occasioned by giving lines and grades, but such compensation shall be considered as having been included in the prices stipulated in the regular items of the contract.

(b) Whenever, in the plans and specifications, or in the orders given thereunder, there are given survey stations, coordinates, or similar designations for the location of the work, it is understood that they are approximate only and no change of such designations shall be made the basis of claims for payment other than that provided in the regular items of the contract.

IV. WORK TO BE DONE

(a) Scope)

The work to be done includes the furnishing of all labor, supervision, materials, tools and equipment, and doing all work required to complete the dam, the dike and appurtenant structures, as called for in these specifications and on the drawings.

(b) Construction Procedure:

The construction program shall at all times be subject to the approval of the Engineer.

The capacity of the plant, the sequence of operations, and the methods of operation, shall be such as to insure the completion of the work within the contract time specified.

Concrete forming the closing plug of the diversion opening shall not be placed until the future power intake and rack structure are completed.

The Contractor shall submit for approval a schedule outlining the entire job giving the starting and completion dates of the various parts of the work.

The entire project must be completed during the year of 1946.

V. RIVER DIVERSION

(a) Description:

The Contractor shall construct and maintain all necessary cofferdams, flumes and other diversion and protective works and shall install, maintain and operate all necessary pumps and other equipment required for unwatering the site of the work, and maintaining the foundation free from water during the time required for construction.

A diversion opening as shown on the drawings shall be left through the dam for passing the flow of water during construction.

This opening shall be solidly filled with concrete after the future power intake, with racks, headgate and bypass valve, has been installed, the time of filling to be subject to the approval of the Engineer. The Contractor shall be responsible for and repair any damage to the dam or other parts of the work caused by floods or failure of any part of the protective works prior to acceptance by the Village. After having served their purpose, the cofferdams shall be removed to such a level as may be necessary to permit the unobstructed flow of water into the intake racks and in any case all wooden parts of the cofferdam shall be removed and burned or otherwise disposed of.

(b) Measurement and Payment:

The cost of furnishing all labor and materials and constructing and removing cofferdams, diverting the river and any other work required by this paragraph except, the placing of concrete in the diversion opening through the dam shall be included in the lump sum bid in the schedule for river diversion.

One half the lump sum bid for river diversion will be paid to the Contractor when the concrete in the main dam and the intake structure is completed to elevation 1160, and the remainder when the diversion opening in the dam has been filled with concrete and all of the temporary structures used by the Contractor for diverting the river have been removed to the satisfaction of the Engineer.

VI. EXCAVATION

(a) Classification:

Except as otherwise provided in these specifications, all material removed from excavation will be measured in excavation only to the neat lines shown on the drawings or prescribed by the Engineer and will be classified as follows-

Rock Excavation

All solid rock in place which cannot be removed until loosened by blasting, barring or wedging and all boulders or detached prices of solid rock more than 1/2 cubic yard in volume. No material except boulders and detached pieces of solid rock will be classed as rock excavation which is not actually loosened by blasting before removal, unless blasting is prohibited, and barring, wedging or similar methods are prescribed by the Engineer.

Disintegrated Rock

All disintegrated rock which can be efficiently removed by excavating machinery and without blasting.

Earth Excavation

All soft overburden not including disintegrated rock which can be removed by sluicing or with excavating machinery.

No additional allowance over the unit prices bid for excavation will be made on account of any of the material being wet or frozen.

(b) Blasting:

Blasting will be permitted only when proper precautions are taken for the protection of persons, the work and private property, and any damage done to the work or to property shall be repaired by the Contractor at the Contractor's expense. Explosives shall in no case be stored, transported or kept in the same place in which dynamite or other explosives are stored, transported or kept. In general, the precautions taken to prevent accidents shall be subject to the approval of the Engineer, but the Contractor shall be liable for all injuries to or death of persons, or damage to property caused by blasting or explosives. Electric blasting machines shall be used on all work.

(c) Excavation for Foundations:

The excavation for the dam foundations shall be made to a sufficient depth to secure foundation on sound ledge rock, free from open seams or other objectional features. Unusual precaution shall be taken to preserve the rock outside of the line of excavation in the soundest possible condition. Blasting may be done only to the extent directed by the Engineer with explosives of such moderate power and in such locations as will neither crack nor damage the rock outside of the prescribed excavation limits. Whenever, in the opinion of the Engineer, blasting is likely to injure the rock upon or across which concrete is to be placed, the use of explosives shall be discontinued and the excavation completed by wedging, barring and picking, or other suitable methods. The excavation shall be roughly shaped, as directed by the Engineer to approximately horizontal steps, at least 8 ft. high and separated by approximately horizontal planes. Special care shall be taken in excavating these steps to avoid shattering or damaging the adjacent rock.

(d) Limits of Foundation Excavation:

The earth and loose rock shall be excavated on the steepest practical slopes with the following modification. Where soft overburden is encountered the slopes shall not be less than 1:1 and the toe of the slopes shall not be less than 30" from the beginning of the rock cut.

Where rock is encountered the slopes shall not be less than 1/4:1. Solid rock shall be excavated as close as practical to the neat lines of the structure. The soft overburden shall be removed for a distance of 12 feet upstream and downstream from the face of the concrete.

The drawings refer to and show "sound rock" contours and elevations determined from diamond drill core borings. These contours and elevations were used in the design of the dam. The actual sound rock elevation will be determined by the Engineer after an inspection of excavation.

If the [illegible] sound rock elevation so determined differs more than 5 ft. [illegible] contours shown on the contract drawings it may be necessary to relocate the dam.

The Contractor shall have no right for claims due to delay that may be necessary to make changes in the design.

(e) Disposal of Materials:

Materials may be disposed of above the dam below elevation 1145. The trench excavation from the face shall not be backfilled. At the downstream side of the dam, backfill shall be provided and grading shall be done in accordance with the drawings.

Excavated materials not used for backfill shall be disposed of in a manner and at locations approved by the Engineer. All spoil banks shall be located where they will not interfere with the natural flow of the river or with the discharge from the outlet gate or spillway. Spoil banks shall be located where they will not detract from the appearance of the structure or interfere with the accessibility of the structure for operation. Spoil banks shall be leveled and trimmed to reasonably regular lines and the Contractor shall not be entitled to any additional compensation on account of such refinement. All combustible material such as trees, logs, brush or roots required to be removed from the excavation for the dam or other works, or from the sites of the spoil banks or otherwise, shall be piled and burned under the direction of the Engineer. The cost of disposing of all excavated material that is wasted shall be included in the price bid for the excavation.

(f) Measurement and Payment:

Measurement and payment will be made to the prescribed neat lines of the excavation and at the unit prices bid in the schedule. Backfill will be measured for payment in place and paid for at the price bid in the schedule. Any excavation outside of the limits prescribed which is required to be backfilled shall be done by and at the expense of the Contractor.

VII. FOUNDATION PREPARATION

(a) Description:

After the sound rock elevation has been determined and the minimum excavation required has been completed the base rock shall be prepared for the building of the dam.

The surface of the rock shall be left rough so as to bond well with the concrete, and where necessary shall be cut to rough benches or steps as directed by the Engineer to secure the required roughness. Care must be taken not to shatter or disturb rock foundations unnecessarily. All loose fragments, dirt and spalls must be removed from the rock surface before concrete is poured. Wire brooms, hammers, picks or streams of water, air or steam or other effective means shall be used to clean the foundation.

(b) Grouting Base Rock:

The base rock underneath the dam shall be prepared by thorough cement grouting. The purpose of this grout is to provide a water-tight curtain below the dam along its upstream face and also to provide a uniform consolidated foundation for the dam. While the general scheme of grouting to be employed is shown on the drawings, the depth and location of borings is illustrative only, and may be different when the excavation is made and the exploration holes are drilled.

...% of the total number of grout holes shall be ... drills, 1-7/8 in. core. The location of these ... designated by the Engineer, and the record of ... shall be kept and the cores properly preserved. ... borings shall extend a minimum of 30 feet below ... end, if the last 10 feet of the hole does not ... rock, the hole shall be extended up to a depth ...

... of the exploration holes has been made, grout holes ... a depth as the Engineer may determine. All grout ... with jack hammers, or by any other method, and shall ... of 1-1/2 in.

... ding grouting, each hole shall be thoroughly cleaned ... to the bottom of the hole and pumping water through ... pipe ... flow of clean water is returned from the hole. ... established, the pumping of water shall be continued at least 15 ... the end of which time the hole shall be dried with compressed air, ... carefully removed and the hole filled with grout, plugged, and ... ed to the grout pump which shall be kept pumping until a pressure ... per sq in. is established. The pressure shall be maintained ... until the hole refuses to take additional grout and for 15 minutes. If this cannot be accomplished, additional holes shall be drilled in the vicinity of the unsatisfactory hole and shall be grouted in the manner.

Holes shall be drilled and grouted in the sequence shown on the drawings. A complete record shall be kept of the time each hole was drilled, washed and grouted, and also the amount of grout admitted during each 10-minute interval shall be recorded.

Grout for the base rock shall be composed of cement and water, or cement, sand and water, in proportions to be determined by the Engineer. Sand shall be clean, and of such fineness that 100% will pass a screen with 64 openings per square inch, and 50% will pass a screen with 1600 openings per square inch. The apparatus for mixing and placing the grout shall be of a type approved by the Engineer and capable of mixing and stirring the grout and forcing it continually into holes at any desired pressure up to 100 lb per sq in. If during the grouting of any grout hole, grout is found to flow from adjacent holes in sufficient quantity to seriously interfere with the grouting operation, or to cause loss of grout, such holes shall be temporarily capped. Where such capping is not essential, ungrouted holes shall be left open to facilitate the escape of air and water as the grout is forced in.

Grouting of base will be paid for at the unit price bid in the schedule and shall include the cost of labor, material, plant and operations incident to the grouting. Materials for grout will be measured dry as they are placed in the grouting machine, and payment will be made for each batch or fractional batch actually forced into the holes. No payment will be made for grout lost or rejected.

VIII. CONCRETE

(a) General Requirements:

Materials and methods of mixing, placing, curing and finishing concrete shall be as specified and recommended in "Recommended Practice and Standard Specifications for Concrete and Reinforced Concrete" by the joint report of a committee comprising representatives of American Society of Civil Engineers, American Society for Testing Materials, and other organizations, published in the Proceedings of the American Society of Civil Engineers in the June 1920 issue.

Concrete for all parts of the work shall be 3000# concrete.

(b) Concrete Materials and Proportions

Alternate "B" of the aforementioned publication shall be followed with additional stipulations as follows:

Estimated 28-day Compressive Strength Lbs per Sq In.	Min. Sacks (94 lb) Cement per cu yd Concrete	Max. Water per Sack Cement Gal.	Max. Size Agg. Passing thro' Ring Dia.	Fine Agg. % Total Agg. by Wgt.	Slump Inches	Approx. Weights Saturated Surface Dry Aggregates per sack of cement: Fine Agg. Lbs.	Coarse Agg. Lbs.
3000	6.0	6-1/2	2-1/2"	38-44	3	210	310

Cement shall be purchased from manufacturers approved by the Engineers.

Materials shall be carefully selected, of uniform quality, and proportioned to secure as nearly as possible maximum density. Aggregates shall be graded so that the smaller particles fill the spaces between the larger, thus reducing the voids in the aggregate to a minimum.

The Contractor, in his bid, shall state the source of both fine and coarse aggregate upon which his bid price on concrete is based.

The proportions given above are subject to such modification as will produce the most economical concrete possible, having an ultimate compressive strength at the age of 28 days of 3000 lbs per sq in. The exact proportions to be used for the different parts of the work will be determined by the Field Engineer after analysis and tests have been made of the samples of accepted aggregates furnished by the Contractor. The Field Engineer shall at frequent intervals make such additional tests and analysis of concrete materials and the resulting concrete and such changes in the proportions as may be necessary to secure the required economy or strength, and the Contractor shall be entitled to no additional compensation because of such changes.

(c) Use of Vibrator

In addition to the strength requirement, it is essential that the concrete be uniformly dense and free from segregation and honeycomb. Only sufficient water shall be used to secure workability, as determined by the Engineer, to flow properly into place with thorough spading and working.

In general, a consistency corresponding to a slump, not greater than 3 in., shall be used. If it appears after test that the concrete materials are such that dense concrete cannot be formed without the aid of vibrators, the specified slump shall be increased so that when vibrated a uniform flow will result. The vibrators used, whether of the internal type operated by the workmen and shall have a frequency of not less than 6000 rpm under load, with an effective vibrating radius such that insertions are required not more than 12 in. apart.

All concrete shall be left for a minimum period of 15 minutes before vibrating in any manner. The concrete shall also be placed continuously and in such successive layers of thickness as may be determined by the Engineer. When sufficient time has elapsed to allow vibration to begin, the operator shall be instructed in the use of the vibrator, which method shall be determined at all times. Vibrating shall be applied only inside the concrete batch and shall not come in contact with the forms.

(d) Forms

It is suggested that the Contractor use panel forms for the main body of the dam with suitable devices to hold adjacent ends and edges of panels tight and in accurate alignment. All forms shall be wired each time before being used with suitable non-stretching wire satisfactory to the Engineer. Metal rods or similar devices to hold the forms will be allowed in the structure provided proper means are used to take out a portion of each rod nearest the surface, at least 2 in. in length. All holes left after removal of the rods shall be filled immediately and completely covered with cement mortar and the surface left smooth and in good condition. If wire ties are used they shall be cut off closely to the concrete after the forms are removed. Wood forms shall be wet thoroughly before placing concrete. Where forms are placed in sufficient units for continuous surfacing, care shall be exercised to set the forms tightly over the completed surface, so as to prevent leakage of mortar from the concrete. Forms shall be left in place until their removal is authorized by the Engineer and shall then be removed by the Contractor with care so as to avoid injury to the concrete. Permanent galvanized steel forms shall be furnished and left in place for all air vents in the spillway. The cost of forms shall be included in the prices bid for concrete.

(e) Defective Concrete

Damaged concrete from any cause or defective concrete which shall be found defective at any time before the completion and acceptance of the work shall be removed and replaced by the Contractor at no expense to the Owners.

(f) Reinforcing Steel

Reinforcing steel shall be deformed bars rolled from intermediate grade new billet steel, free from rust, scale or coatings which would tend to reduce the bond. The Contractor shall furnish the Engineer with detailed shop drawings for approval. Reinforcing bars shall be so secured that they will not be displaced during the placing of concrete.

Payment for reinforcing steel will be made at the unit prices bid in the schedule, which price shall include the delivered cost of the steel and the cutting, bending, placing, wiring and maintaining of the same as shown on the drawings or as directed by the Engineer.

(c) [illegible]

[illegible] net lines of the structure. The measurement will include only the actual net volume of [illegible] within the neat lines of the structure and the volume of [illegible], embedded pipe and metal work, except reinforcing steel and anchors will not be included. Payment for concrete will be made at the unit price [illegible] and shall include the entire cost of all labor, [illegible] and forms, except reinforcing steel.

IX. [illegible] CONCRETE WORK

(a) [illegible] in Dam

The [illegible] in the foundation and the top of the abutment shall be built of [illegible] lb concrete in alternate lifts or blocks with vertical contraction joints as called for on the drawings. One or more of these checks may be maintained at a lower elevation than the adjacent ones as a safeguard against damage by flood. It is intended that the blocks be built in horizontal lifts approximately 8 ft high, which lifts shall be made in one pouring.

(b) Concrete in Apron

The foundation of the apron shall be carried to reasonably sound rock into which holes shall be drilled 40 inches on centers for the placing of vertical 1 in. diameter dowels which shall be embedded at least 3'-6" into sound rock and grouted. The apron shall be 3000 lb concrete poured in blocks approximately 12 ft square and 3'-6" thick, and reinforced with 1 in. round bars 12 in. on centers in both directions. This reinforcement shall be placed 6 in. below the finished surface of the concrete. The joints between adjacent blocks shall be filled with asphaltic compound. No reinforcement shall project through these joints.

The top surface of the apron shall conform to the detailed drawings which will be furnished by the Engineer and shall be integrally finished with steel trowels followed by a wooden float.

(c) Concrete in Stairway

The concrete in the stairway shall be 3000 lb concrete built to the lines and dimensions shown on the drawings or prescribed by the Engineer. All reinforcement and embedded steel and iron work shall be checked before concrete is poured. The treads are to be troweled smooth and finished with wooden floats. Pipe inserts are to be set in stairs to support pipe railing.

(d) Concrete in Gate and Valve Houses

The concrete in the gate and valve houses is to be 3000 lb concrete built to the lines and dimensions shown on the drawings or prescribed by the Engineer. All reinforcement and embedded steel and iron work shall be checked before concrete is poured. The roof of the gate house at the top of the dam shall be waterproofed and finished integrally with steel trowel and left smooth. No roofing will be required for this structure. The roof covering of the valve house shall be 5-ply tar and gravel Barrett specifications, or equal.

(e) [illegible] - [illegible] iron [illegible] the strength of [illegible], free from [illegible] or [illegible]. [illegible] and drilled to match the drilling on the face of the [illegible] valve.

(f) [illegible] - A 6" diameter welded steel pipe shall be welded into the top [illegible] and [illegible] to a point near the [illegible] where it will pass out through the upstream face at the elevation shown on the drawing. The vent pipe will be paid for at the lump sum bid in the schedule.

(f) Protective Coating - All structural cast iron shall be given one shop coat consisting of red lead, linseed oil and turpentine.

Machine finished surfaces shall be protected from corrosion.

After the pipe has been erected in the field and the riveting of the same completed, the inside of the pipe shall be given two coats of "Inertol" manufactured by the Inertol Company, Inc. The outside of the pipe where not encased in concrete shall be given two coats of Inertol.

(g) Measurement and Payment - Payment will be made for the pipe erected at the price per ton bid in the schedule.

XII. HEAD GATE

(a) The head gate is to be a 6'-0" diameter Dow valve with a bell mouth and flange to connect to the upstream end of the penstock. The gate will have an operating device passing through the dam at an angle of 45° with the necessary stuffing box and electrically operated floor stand.

The above equipment will be furnished together with flange bolts by the Owners under another contract.

(b) Painting - The above equipment will have one shop coat of red lead and oil. After erection, the exposed steel and iron parts will be painted as specified under Structural Steel.

(c) This Contractor is to receive the equipment at the railroad station, unload from the cars, truck to the site, and erect the same at the lump sum price bid in the schedule.

XIII. DISCHARGE VALVE

(a) A 2'-6" diameter Dow discharge valve will be furnished by the Owners under another contract for installation in the by-pass pipe. The valve will be furnished with flange bolts.

(b) Painting - The above equipment will have one shop coat of red lead and oil. After erection, the exposed steel and iron parts will be painted as specified under Structural Steel.

(c) This Contractor is to erect this valve together with incidental equipment at the lump sum bid in the schedule.

XIV. [illegible]

[illegible]. - Description - The dike is to be of earth with a top width of 20 feet and a top length of about 400 feet. The maximum height above the natural surface is about 20 feet. The core will be carried to an impervious material about 11 feet below the surface. The core will be constructed of impervious material to be obtained in the general vicinity of the dike location. The dike is located about [illegible] feet from the Garfield-Carlisle county road. The Contractor will be required to prepare the construction road from the town road to the dike site.

Item 2.

(a) Stripping - Before the excavation for the core trench is begun, the Contractor shall remove from the area under the embankment and satisfactorily dispose of all top soil to the depths directed, peat, silt, muck, loose rock, highly organic or other unsatisfactory materials. No stripping of borrow areas or other areas outside the area under the embankment shall be included under this item, even though stripping may be needed to render the underlying materials acceptable. Stripping shall be extended only to the depths from the original surface as are ordered to be necessary to remove unsatisfactory materials.

All grubbing of stumps and roots in the area under the dam and to a distance of 25 feet easterly and westerly from the toes of the embank ment shall be included under this item.

The site of the dike and areas easterly and westerly from the dike are in general covered with a top layer of about 30 in. thick of relatively impervious material underlaid by a layer of more pervious material. The layer of impervious material shall not be cut into in the stripping operations under the dike beyond that necessary to remove the unsatisfactory materials except where excavation is required for the core trench. The impervious material shall not be disturbed on the pond side of the dike, and shall not be disturbed on the easterly side of the dike for a distance of about 200 feet from the toe of the dike. Any materials removed from these areas shall be replaced with compacted impervious material to the original surface.

(b) Disposal - The Contractor may use suitable stripped material, to the extent permitted, in the construction of the embankment. All unsatisfactory materials shall be wasted to prescribed lines and grades in spoil banks in permitted locations between the embankment and the town road. Trees, stumps, roots and other burnable material shall be burned or otherwise satisfactorily disposed of.

(c) Payment - Payment will be made for the number of cubic yards removed and satisfactorily disposed of in accordance with orders, measured in place before excavation. The price stipulated shall include payment for all grubbing of stumps and roots in the area stripped and to a distance of 25 feet outside the toes of the dam, for refill of impervious materials as specified under (b) of this item, and for the disposal of all materials which are not used in the embankment. The measurement for payment shall not include materials re-excavated from temporary storage piles, or materials excavated from borrow pits or from any areas whatever, ordered or permitted to be stripped for the purpose of obtaining materials.

Item 3. - Core

(a) Excavation - The excavation for the core shall be carried to impervious material which in general is about 11 feet below the present surface. The materials through which the excavation is to be carried consists of about 30 inches of top soil and 6'-6" of glacial till. The trench is to have a bottom width of about 2 feet with side slopes of about one on one. Suitable materials excavated may be stored in piles and used in the embankment of the dike.

(b) Payment - The quantities to be paid for under this item shall be the number of cubic yards excavated and satisfactorily disposed of in accordance with plans or orders, measured as specified in place before excavation. The prices stipulated shall include payment for the disposal of all excavated materials which are unsuitable for use in the embankment of the dam. The measurement for payment shall not include materials excavated from borrow pits; or materials excavated for Contractor's roads, camps, drains, sanitary works or for other temporary or construction purposes; or materials re-excavated from storage piles; or materials from unauthorized excavations; or materials excavated by permission outside ordered limits. Neither shall it include any re-handling of materials in the construction of the dike nor any excavation of embankment material even though such excavation may be necessary or required for the proper trimming and grading of slopes.

Item 4. - Embankment

(a) Work to be Done - Under this item the Contractor shall furnish, transport, place, grade and consolidate acceptable materials, within the limits shown on the plans or ordered, in the refill of the core trench, in the embankment of the dike inside the stone fills and beneath the rip-rap, including the refill of volumes under the dike stripped under Item #2, and any other ordered refill and embankment work adjacent to the dam except those specifically ordered under other items.

(b) Quality - Several classes of materials will be required for use under this item, and in general each class of material shall satisfactorily fulfill the specific purposes for which it is intended.

Impervious Materials - The refill of the core trench and the core of the dike embankment shall be built of suitable materials of satisfactorily impervious quality. Acceptable and impervious top-soils and sub-soils obtained from the stripping may also be used if satisfactorily free from vegetation, masses of roots, or other objectionable materials. Additional materials as required may be obtained from approved borrow pits.

Shoulder Materials - Materials placed within the limits shown on the [illegible] core and the toes of the dike, shall generally [illegible] used in the core. The types of materials used in these locations may vary from relatively watertight, impervious materials, to coarse, free draining pervious materials, and although there is a wide range of acceptable types,

impervious placed adjacent to the core, or in other suitable locations, and the semi-pervious placed adjacent to the shoulders. Suitable materials from the required excavations may be used, or the materials may be obtained from selected borrow pits. [illegible] in the dike and fills of the dikes. All organic matter, trash, previous, free-draining materials available in the vicinity of the dike.

Pervious Materials under Downstream Shoulder of Dike - The surface of the soil [illegible] for the embankment shall be covered with a layer of pervious material on the assembly limits of the core and the exterior [illegible] as shown on the plans or ordered. The pervious materials shall consist of selected sand and gravel, placed under the direction of the Engineer with the sand next to the core, grading into gravel toward the toe of the dam as indicated on the plans. The gravel shall consist of coarse sand and small stones as obtained from selected borrow pits.

(c) Placing - The embankment of the dike shall be started on a base which shall have been cleared under item #1, which shall have been stripped and grubbed to the extent ordered under item #2, and which shall have been rolled to the extent ordered for firmness. Materials placed under item #4 shall, unless otherwise permitted or required, be deposited in horizontal layers and thoroughly compacted by rolling. The core and embankment materials shall be rolled in layers 6 inches thick after rolling, unless sheepsfoot rollers are used having 7 in. teeth, in which case the layers may be 8 in. thick after rolling.

In general, the embankment work shall be carried on in such manner that the core construction is maintained about 2 feet higher than work on adjacent shoulders, allowing drainage of water from the surface of the core freely.

Materials placed, unless sufficiently moist as spread, shall be wetted to the extent directed. It is expected that the moisture content of materials in the adjacent borrow areas is sufficiently high so that no wetting will be required. If, however, in the opinion of the Engineer, the moisture content of the materials coming from the borrow pits is unsatisfactorily high to obtain the proper consolidation, the Contractor shall undercut and drain or otherwise dry out his borrow pits to render the materials borrowed satisfactory, or shall shift his borrow operations to more satisfactory locations. Proper consolidation can probably be obtained with moisture contents of from 10 to 20 percent of the dry weight of the material for impervious material, and from 10 to 15 percent for shoulder materials.

Material placed shall be rolled as directed, with an approved roller, either of the sheepsfoot type weighted as required, or of a self-propelled, banded, three wheel type, weighing not less than 12 tons, the resulting pressure under the rear wheels of which shall not be less than 500 pounds per inch width of wheel. The roller shall pass over every part of each layer that can be traversed by it, and the number of trips required for satisfactory consolidation for each type of material will be specified by the Engineer as the work progresses. The number of trips required will probably be more than six but less than ten.

Portions of refills or embankment which the rollers cannot reach for any reason shall be compacted by tamping mechanically with extra heavy tampers [illegible], or by other means which will secure a degree of compaction equal to that obtained by rolling as specified. Where shown on the plans or ordered, the new soil shall be placed and compacted in layers [illegible] thicker than after it is in its compacted condition, and in no case more than 6 inches thick for other portions of the embankment. No work shall be done in the placing of the rolled refill or embankment during periods of inclement weather, or at other times or periods when, in the opinion of the Engineer, the weather is such as to interfere with proper construction. No frozen material shall be used in the construction of rolled earth fills, nor shall materials be dumped upon foundations or fills which contain frost.

(d) Payment - The quantities to be paid for under Item #4 shall be the number of cubic yards placed in accordance with orders, measured in position after compacting. The price stipulated shall include payment for preparing the base except for such clearing, grubbing and stripping as may be ordered under Item #2; borrowing, transporting and placing of materials; spreading in layers, wetting, rolling, tamping, trimming to line; and all labor and materials incidental to satisfactorily completing the embankments of the dike. The measurement for payment shall not include spoil banks, or refilling of unauthorized excavations, or material placed outside the prescribed lines even though such material may have been so placed with the permission or at the direction of the Engineer immediately adjacent to or continuous with prescribed embankments. No direct payment shall be made under this item for refilling and embanking of whatever nature made solely for the Contractor's plant, camp, roads, or for his requirements in carrying out the provisions of this contract.

Item 5. - Riprap and Stone Fills

(a) Work to be Done - The Contractor shall furnish all materials, equipment and labor required to construct, within the limits shown on the plans or ordered, the riprap on the easterly and westerly faces of the dike embankment, and the stone fills in the easterly and westerly toes of the dike.

(b) Quality - Riprap and stone fills shall be composed of durable stone of acceptable sizes. Satisfactory rock, boulders, and large cobbles from the excavation for the core trench, and suitable boulders and large cobbles from the borrow pits, may be used in the construction. The Contractor shall furnish stone of satisfactory sizes and quality for any part or parts of this stonework construction from approved sources to fulfill any deficiency of suitable excavated rock needed to complete the minimum stone fill requirements as shown on the plans or ordered.

Riprap on the westerly face of the dike shall consist of such sizes that for any volume of 50 cubic yards or more at least 20 percent shall be larger than 1 cubic foot; at least 50 percent larger than 1/2 cubic foot; and [illegible] percent larger than 3 inch ring size.

[illegible] on the easterly face shall have no broken stone or gravel small enough to pass a 2 inch ring; and at least 50 percent of any volume 50 cubic yards or more shall consist of stones exceeding 4 in. diameter size, and at least 20 percent stones exceeding 6 in. average diameter size.

The sizes of stone required for the stone fills shall be such that stone fills are, in the opinion of the Engineer, satisfactorily free from spalls, chips, and muck, and do not contain excess quantities of chips and finely broken rock fragments.

All riprap and stone fills shall contain a sufficient number of angular stones to give stability to each entire mass.

(c) Placing - The Contractor will not be required to place riprap or stone fills by hand except to rearrange surface stones as necessary to fill unsatisfactory depressions in the surfaces below the required grades. The finished surfaces shall satisfactorily approximate the required theoretical.

(d) Payment - The quantity to be paid for under this item shall be the number of cubic yards satisfactorily placed in the completed work, measured as specified and to the ordered theoretical surfaces regardless of the quantities of riprap or stone fills projecting beyond such surfaces and with no deduction for the voids.

The prices respectively stipulated shall include payment for all work directly or indirectly connected with furnishing, placing, and trimming the riprap or stone fills.

(h) The retaining walls, apron, and weir shall be constructed in the dry and the required cofferdam work shall be installed and maintained until ordered removed by the Engineer.

(i) Diversion Opening. - Furnish complete and install the gate and gate frame as detailed on the drawings at the upstream end of the diversion opening. The timber gate will be set in the open position until the sluiceway is to be filled with concrete, when the gate shall be lowered to the closed position, caulked watertight to the seat and left in place. Furnish and set in place flush with the downstream face of the dam a temporary watertight bulkhead over the downstream end of the sluiceway, caulked watertight to the concrete. After concrete has hardened in the sluiceway, remove the bulkhead.

(j) Timber. - Shall be spruce or southern pine of a quality that will mill straight and true and make a watertight gate under hydrostatic pressure, dressed four sides, grooved for, and have splines of same material, Gate seat framed, tenoned and pinned, Sliding surfaces of gates and frame smooth and true to line.

(k) Ironwork. - Include all anchors bolted to woodwork and built into the concrete, all bolts, washers and nuts, stay rods, turnbuckles and eye-bolts, wire rope suspension and arm built into concrete. Iron work will not be painted.

(l) Gate Assembly. - Holes for the longitudinal bolts shall be laid out to template and bored 1/16" larger than the bolts. All other holes shall be the same diameter as the bolt. After gate members are assembled the through bolts tightened, the side bearing strips shall be placed and the holes bored for the through bolts. The splined members of the gate shall be put together with a heavy coat of white lead and oil thoroughly applied to the splines and joints.

(m) Removal. - Having fully served their purpose all cofferdam work, and all sheet piling and other diversion works shall be removed to such a level as may be required to allow the unobstructed flow of water into the intake rack. All parts of cofferdam and diversion material below the dam shall be completely removed. In all cases all wooden parts of the cofferdam and diversion shall be burned or otherwise disposed of as directed.

(n) Payment. - The total cost of furnishing all materials, and labor for constructing, maintaining and removing all cofferdams, river diversion methods including gate, frame and downstream closure form of the temporary sluiceway, and any and all work required under the Contract Item #1 shall be included in the lump sum stated in the Contract for Item #1, River Diversion.

SECTION IV

THE DAM

ITEM #1. RIVER DIVERSION

(a) General. - The Contractor shall construct, and maintain all necessary cofferdams, sheet piling, flumes and all other diversion and protective works and shall install, maintain and operate all necessary pumps and other equipment required to dewater and maintain free from water any and all parts of the work during the time required for construction.

(b) Damage. - The Contractor shall be responsible for and repair, at his own expense, any damage to the dam or other parts of the work caused by floods or failure or insufficiency of any part of the protective works at any time prior to the final acceptance of the completed work by the Owner.

(c) Cofferdams. - May be constructed in such a manner as may be proposed by the Contractor, providing the same is satisfactory to the Engineer, but the responsibility for proper construction and maintenance and efficiency shall rest entirely with this Contractor. Cofferdams shall be substantially constructed and made watertight.

(d) Pumping. - Sufficient pumping equipment shall be installed and maintained to keep the enclosures free of water and no concrete shall be installed in water nor shall any water be allowed to come in contact with any concrete less than 4 days old.

(e) Order of Work. - At the option of the Contractor, work will be started on the easterly side of the dam and the cofferdam and sheathing shall be constructed to allow excavation, drilling and grouting of base and placing of concrete under dry working conditions. The concrete work on the dam will be carried to a height above the top of the temporary sluiceway.

(f) The westerly cofferdam work shall then be constructed to include the end of the concrete already in place and of sufficient height to send the flow through the temporary sluiceway. The construction work will then be carried to the same elevation as already installed on the easterly side.

(g) The stream flow will now pass through the temporary sluiceway left in the concrete construction until the dam, valve houses, and penstock are completed. The temporary sluice gate will then be closed, the temporary form set closing the downstream end of the temporary sluiceway. The sluiceway will be filled with concrete, as specified under "Concrete Work in Dam".

(c) One half the amount of the lump sum for River Diversion shall be paid to the Contractor when the concrete work in the dam and the structure is completed to El. [illegible] and the river diversion [illegible] and all of the temporary structures used by the Contractor for River Diversion have been removed to the approval of the Engineer.

ITEM #2. EARTH EXCAVATION, DAM SITE

(a) General. - All applicable specifications in Sec. II "Excavation and Backfill, General" shall be a part of this Item #2 so far as the same may apply.

(b) Scope. - Includes all grubbing and all excavation of earth and loose rock to bed rock as required for the construction of the concrete dam, apron, valve houses, retaining walls and the weir, and the installation of the penstock, and discharge pipe.

(c) The earth and loose rock shall be excavated with the steepest practicable slopes. Where overburden is encountered the slopes shall not be steeper than the lines established by the Engineer. The overburden shall be stripped to the ledge upstream and downstream from the dam as shown on the drawing.

(d) Disposal of Material. - In general as specified in Sec. II "Excavation and Backfill, General". All combustible material, logs, brush, stumps and roots removed in excavating shall be piled and burned and all refuse removed as directed. Suitable material can be stock-piled and be used as backfill to the extent required.

(e) Measurement and Payment. - Measurement will be made to the neat lines as indicated or as established by the Engineer. Payment will be made at the contract unit price as given for Item #2 Earth Excavation.

ITEM #3. ROCK EXCAVATION

(a) General. - All applicable specifications in Sec. II "Excavation and Backfill, General" shall be a part of this Item #3 so far as the same may apply.

(b) Scope. - Includes all rock excavation and preparation of ledge surfaces to receive concrete work required for the construction of the concrete dam, apron, valve houses, retaining walls and the weir and the installation of the penstock and discharge pipe.

(c) Work Not Included. - This Item #3 does not include the cost of any core or grout hole drilling, line drilling, grouting or any concrete work.

(d) Extent. - Rock excavation shall be made to the neat lines and grades as shown on the drawings and may be further [illegible] by the Engineer. It shall be made to such [illegible] as to secure a solid and satisfactory foundation for concrete on sound ledge rock, free from open seams, loose strata or other objectionable features.

Extra care shall be taken to preserve the rock outside of the lines of excavation in the soundest possible condition.

(e) Design. - The drawings refer to and show "sound rock" as indicated by core borings. These borings were used as basis for the design of the dam. The actual "sound rock" lines will be finally determined by the Engineer after an inspection of the rock exposed by excavation of the overburden and any soft rock.

(f) Shaping. - The surfaces of the rock for the dam foundation, shall be roughly shaped, as directed by the Engineer, to approximately level steps approximately 8 feet high, Special care shall be taken in excavating and shaping these steps to avoid shattering or damaging the adjacent rock structure. Solid rock shall be excavated as closely as practical to the neat lines of structures and slopes as shown.

(g) Foundation Preparation. - After the sound rock elevation has been determined and the minimum excavation required has been completed, the base rock surfaces shall be prepared for the installation of the concrete work. The surface of the rock shall be left rough to bond with the concrete, and where advisable shall be cut to rough benches or steps to secure the required roughness as directed by the Engineer. All loose fragments, spalls, and dirt shall be removed from the rock surface before concrete is poured. Wire brooms, hammers, picks and streams of water, air or steam or other effective means shall be used to thoroughly clean the surfaces on which concrete is to be placed just before the concrete is deposited.

(h) Blasting. - Shall be done only to the extent as directed by the Engineer with explosives of such moderate power and in such locations as will neither shatter, crack nor damage the rock outside of the prescribed rock excavation limits. All blasting operations shall be conducted as specified under Sec. II "Excavation and Backfill, General".

(i) Wedging. - Whenever, in the opinion of the Engineer, blasting might injure the rock upon or across which concrete is to be placed, the use of explosives shall be discontinued and the excavation work completed by wedging, barring and picking or by other approved means.

(j) Disposal of Materials. - Excavated materials shall be disposed of in a manner and at locations designated by the Engineer. Materials may be disposed of above the dam below El. 1145, or downstream from the dam in such locations as will

not encroach on the river.

(e) Measurement and Payment. - Measurement will be made to the neat lines as indicated or as established by the Engineer. Payment will be made at the contract unit price as given for Item #3 Rock Excavation.

ITEM #4. BACKFILL

(a) General. - All applicable specifications in Sec. II "Excavation and Backfilling, General" shall be a part of this Item #4 in so far as the same may apply.

(b) Scope. - Backfill shall be placed in the areas and to the grades as shown on the drawings and will be, in the areas back of the Valve Houses and the retaining walls and in other locations if directed.

(c) Material. - Only suitable and approved material shall be used and it shall be thoroughly compacted in place and graded to drain away from structures and retaining walls as shown.

(d) Measurement and Payment. - The quantity to be paid for under Item #4 Backfill shall be the number of cubic yards placed in accordance with the drawings or as directed by the Engineer, measured in place after compacting. The measurement for payment shall not include refilling of unauthorized excavations nor any materials placed outside the indicated lines.

Payment shall be made at the contract unit price for backfilling. The price stipulated shall include all costs of every kind in connection with this item of backfilling. It shall include all costs incidental to the procuring and hauling of backfill from spoil banks or borrow pits or any other source of material.

ITEM #5. LINE DRILLING

(a) General. - Where indicated on the drawings or as directed by the Engineer, rock surfaces approximately vertical shall be prepared by line drilling and the excavation adjacent to the rock surfaces shall be made in shallow lifts and short sections in such a manner that the completed surfaces shall be of undisturbed and sound rock.

(b) Drilling. - The spacing of the drill holes shall be such that the rock faces, after blasting, shall be within three inches of the lines shown on the drawings or as directed by the Engineer. All line drilling shall be at an angle of approximately 4 on 1 sloping back from the toe of the steps.

(c) Rock. - All materials removed by line drilling and the necessary blasting shall be classified and paid for under Item #3, Rock Excavation.

(d) Measurement and Payment. - Measurement for Line Drilling shall be based on the square feet of surface computed on the depth of the drilling and the length of the line drilled, and shall between centers of the drill holes at the ends of a line. Payment shall be made on the contract unit price per square foot for Item #5 "Line Drilling". The unit price shall include all costs of every kind incurred in connection with actual drilling operations. It shall not include any costs of blasting or rock excavation as these items are to be included in the costs of Item #3 Rock Excavation.

ITEM #6. DRILLING, CORE HOLES, 30 FEET

(a) General. - The Contractor may be required to do such drilling, core drill and percussion drill, as may be found necessary under the base of the dam as a means to provide a watertight cut-off under the upstream face of the dam and to provide a uniformly consolidated foundation for the dam.

(b) Grout Holes. - The general scheme for the grout holes is shown on the drawings. The Owner reserves the right to change the location, number and depth of grout holes or to omit any or all and no change shall be allowed in the unit contract price because of such changes.

(c) Core Drilling. - Approximately 10% of the grout holes shall be drilled with a core drill which will produce a core with a minimum diameter of 1½ inches, and shall be drilled to a minimum depth of 30 feet below the surface of the sound rock. If found advisable, the depth of the holes may be increased to 50 feet.

(d) Drilling. - The type of drilling equipment shall meet the approval of the Engineer. Core drilling shall be done with a rotary core drill using a diamond or steel allow type drill bit.

(e) Records. - The holes shall be carefully located, records kept of the depth of each and all cores shall be carefully preserved and properly labeled.

(f) Measurement and Payment. - Measurement shall be made from the surface of the sound rock to the bottom of the drilled hole. Payment shall be made at the contract unit price per foot for core holes drilled to a depth of 30 feet. If found advisable and holes are drilled to a greater depth than 30 feet payment will be made under Item #7, Drilling, Core Holes, 31-50 ft. The contract unit price shall include the entire costs of all materials, equipment, transportation and labor required to perform the work.

ITEM #7. DRILLING CORE HOLES 30-50 FEET

(a) All specifications under Item #6, Drilling Core Holes 30 feet shall apply to this Item #7 with the exception that the contract unit price shall be based on the length of holes

drilled to a depth of 30 feet or more as required with a maximum depth of 50 feet.

(b) Measurement and payment. - All conditions the same as under Item #6 except the contract unit price shall be as given for this Item #7.

ITEM #8. - DRILLING, GROUT HOLES, 0-30 FEET

(a) General. - The Contractor may be required to do such drilling of grout holes in the rock under the base of the dam as may be found advisable to be filled with cement grout to provide a watertight cut-off under the upstream face of the dam and a uniformly consolidated foundation for the dam. After a study of the cores of the core holes has been made, grout holes may be directed to be drilled on such spacing and to such depths as the Engineer may direct.

(b) Specifications. - All specifications for drilling under Item #6 Drilling, Core Holes, 30 Feet shall apply to this item except that drilling may be done with a percussion drill, no core material shall be saved, and drill holes shall have minimum diameter of 1½ inches.

(c) Measurement and Payment. - Measurement shall be made from the surface of the sound rock to the bottom of the drill. hole, as drilled, not to exceed 30 feet. Payment shall be made at the contract unit price for this item. If found advisable to drill holes to a depth greater than 30 feet payment will be made under Item #9, Drilling, Grout Holes, 31-50 feet. The contract unit price shall include the entire costs of materials, equipment, transportation and labor required to perform the work.

ITEM #9. - DRILLING, GROUT HOLES, 31-50 FEET.

(a) All specifications under Item #8, Drilling, Grout Holes, 0-30 Feet, shall apply to this Item #9 with the exception that the contract unit price shall be based on the length of holes drilled to a depth more than 30 feet and not more than 50 feet.

(b) Measurement and Payment. - Measurement shall be made from the surface of the sound rock to the bottom of the drill hole if drilled to a depth of 31 feet or more. Payment shall be made at the contract unit price for this item #9, Drilling, Grout Holes, 31-50 Feet. The contract unit price shall include the entire costs of materials, equipment, transportation and labor required to perform the work.

ITEM #10. - DRILLING FOR APRON DOWELS

(a) Includes all materials, equipment, transportation and labor required to drill holes in the rock required for steel dowels to be inserted in the drill holes in the rock formation under the concrete apron below the spillway. Does not include dowels or grouting work.

(b) Drilling. - Drill holes shall be not less than 1½ inch minimum diameter, shall be spaced approximately 40 inches on centers, both ways, and drilled to a depth of 3'-3" below the surface of the sound rock. Holes shall be thoroughly cleaned after drilling and a wood plug driven in to keep the hole free from dirt or debris. The Owner reserves the right to change location and number of drill holes without any change in the contract unit price.

(c) Measurement and Payment. - Measurement shall be based on the total lineal feet drilled and payment shall be made on the contract unit price per lineal foot for this Item #10.

ITEM #11. GROUTING, ROCK FOUNDATION

(a) General. - If it is found necessary by the Engineer to make a watertight cutoff within the rock formation, on which the dam is to be built, by forcing cement grout into the rock structure, grout holes will be drilled as specified under other contract Items. The grouting shall be done under this Item.

(b) Scope. - This Item shall include all labor, equipment, transportation and all materials except Portland cement and steel pipe which will be furnished and paid for under their respective contract Items.

(c) Grout Holes, Preparation. - Immediately preceding grouting, each hole shall be thoroughly cleaned by extending a one-inch pipe to the bottom of the hole and pumping water through the pipe until a uniform flow of clean water is returned from the hole. After such flow is established the pumping of water shall be continued not less than 10 minutes, at the end of which time the water shall be blown from the hole and the hole shall be dried out by compressed air.

(d) The pipe shall be carefully removed and the hole filled with cement grout, and connected to a grout pump which shall keep pumping until a pressure of 100 lb. psi is established and maintained at that pressure and until the hole refuses to take additional grout and for 15 minutes longer. If this cannot be accomplished, additional holes shall be drilled in the vicinity of the unsatisfactory hole and these shall be grouted in the same manner. If necessary low pressure grouting shall precede the high pressure grouting if it is found that the rock is lifted under the higher pressure.

(e) Holes shall be grouted in the sequence as directed. A complete record shall be kept of the time each hole was washed and grouted, and the amount of grout admitted during each 10 minute interval shall be recorded.

(f) Grout. - Shall be made of cement, sand and water in proportions as directed by the Engineer; sand may be omitted

if the Engineer so directs. Sand shall be clean and of such fineness that 100% will pass a screen with 64 openings per sq. in. [illegible] will pass a screen with 1600 openings per sq. in. [illegible] and placing the grout shall be capable of mixing and agitating the grout and forcing it continually into holes at any required pressure up to 100 lb per sq. in. and shall be of a type approved by the Engineer.

(g) If, during the grouting of any grout hole, grout is found to flow from adjacent holes in sufficient quantity to seriously interfere with the grouting operation, or to cause loss of grout, such holes shall be temporarily capped. Where such capping is not essential, ungrouted holes shall be left open to facilitate the escape of air and water as the grout is forced in.

(h) Measurement. - Measurement will be based on the actual cubic feet of grout forced into the rock structure and grout holes.

(i) Payment. - Grouting of base will be paid for at the contract unit price per cubic foot and the unit price shall include the cost of labor material, plant and operations incidental to the grouting. Materials for grout will be measured dry as they are placed in the grouting machine and payment will be made for each batch or fractional batch actually forced into the grout holes. The actual price to be paid for grout used shall not include any costs of portland cement or iron pipe. These materials are provided for under other items. No payment will be made for any grout lost due to clogged lines, improper anchorage of grout pipes or connections, leakage in lines, leakage due to faulty calking, or for grout rejected because of unsatisfactory mix.

ITEM #12. GROUTING VERTICAL JOINTS IN DAM

(a) General. - Includes the grouting under pressure of all the vertical joints in the concrete construction of the dam and the grouting of the concrete plug of the diversion opening after the concrete has set and shrinkage has taken place after the concrete has completely hardened. The actual vertical joint construction including the metal plates and pipes will be included under other sections. The grouting shall be started only when directed by the Engineer.

(b) Grouting. - The grouting of the vertical joints shall be done by the use of two grouting pumps at two symmetrically located vertical joints starting with the two joints at the extreme ends of the dam and moving towards the center, always grouting two symmetrically located joints simultaneously. This Item #12 shall also include the grouting of the concrete plug in the diversion opening as shown.

(c) Procedure. - After the installation of the pumps at two joints, water shall be pumped through the grout pipes into the vertical joints until all air is removed and a rate of flow of water is established through the outgoing pipes, at which time water shall be pumped through the joint for one hour. Without stopping the pump and without interrupting the flow, grout shall be gradually admitted in the pump and the pumping continued until a uniform flow of grout is established through the outlet pipes. The outlet pipe shall then be capped and the pressure shall be built up to 100# psi.

(d) Grouting. - This pressure shall be maintained at 100# psi until the joint will not admit any more grout and for a period of one-half hour thereafter. If the pressure can not be built up during the grouting period due to leakage, the entire pressure shall be released, water admitted in the grouting pipes and pumping continued with water until all grout is washed out. The leak shall then be found and stopped and the entire grouting procedure repeated until the joint is satisfactorily grouted under the specified pressure of 100# psi.

(e) Grout. - Shall be made of cement, sand and water in proportions as directed by the Engineer. Sand may be omitted if the Engineer so directs.

(f) Measurement and Payment. - Shall be paid for at the contract unit price per cubic foot of grout actually forced in place. The contract unit price shall include all costs of labor, equipment, transportation and all materials, except portland cement and steel pipe. Portland cement and steel pipe is furnished and paid for under other Items. No payment will be made for any grout lost due to clogged lines, improper anchorage of grout pipes or connections, leakage from lines, or due to faulty calking, or for grout rejected because of unsatisfactory mix.

ITEM #13. CONCRETE WORK IN DAM

(a) Scope. - Includes all labor, equipment, transportation and all materials except those listed in (b) required to construct the concrete dam to the lines shown on the drawings, listed in the specifications and as reasonably implied by either or both. Shall include filling with concrete of all holes left by removal of pipe.

(b) Not Included. - Portland cement, reinforcing steel wired in place, steel grout pipes, copper grout stops, grouting of vertical joints and grouting around concrete plug in diversion opening.

(c) Specifications. - All specifications in Section III Concrete Work, General shall be considered as a part of the specification for this Item #13 so far as the same may apply.

(d) General. - The dam shall be constructed with concrete in alternating 40'-0" blocks, approximately 8'-0" high with vertical construction joints formed as shown. Each block shall be constructed in one continuous pouring. One or more of the end blocks may be maintained at a lower elevation than the adjacent blocks as a safeguard against damage by flood.

(e) Vertical Construction Joints. - Shall be formed as shown with keyways, grout stops, grouting slots and grouting pipes. The grouting slots shall be formed in the concrete block in which the concrete is to be placed by nailing a wood strip to the form, installing the pipe connections, and setting the nails to secure the metal cover sheet. After the forms are stripped, the grouting slot shall be protected and covered by a sheet iron cover secured in place by bending the nails, previously embedded in the concrete, down over the cover plate.

(f) Protection. - When the concrete is being placed in the adjoining block, the grouting slots shall be kept clean and free from the plastic concrete by blowing compressed air through them, connecting the air supply individually to each grout pipe at the bottom of the block. After the depositing of concrete for the entire dam is completed the grout pipes at the bottom of the different blocks shall be connected by a header just before the final grouting is to be done.

(g) Grout Stops. - Made of copper and as detailed shall be built into the vertical construction joints at all locations as shown or required. The copper strips formed and delivered will be furnished under Item #22 Copper Grout stops.

(h) Steel Pipe. - All steel pipe and fittings required for grouting vertical joints is included under Steel Pipe in Item #20 as delivered and installed in place on the site.

(i) Exposed Joints. - All horizontal and vertical joints on the upstream and downstream faces of the dam shall be formed and accentuated with a V-joint formed by wood strips attached to the forms.

(j) Penstock and Vent Pipes. - Will be hauled to site and erected in place under Item #30, Haul and Set Penstock, Discharge Pipe and Vent Pipe and under this Item the Contractor shall embed in concrete, build all permanent cradles as shown and remove all temporary blocking and bracing.

(k) Diversion Opening. - After the dam is completed with the trash rack, intake etc. in place and as directed by the Engineer the diversion opening and the concrete pouring channels left for that purpose shall be completely filled with 3000 lb. concrete. Grouting of the concrete plug is included under Item #12, Grouting of Vertical Joints.

(l) Furnish and build in a 16 oz. copper reglet on the downstream face of the dam to receive the roof flashing on the Intake Valve House. Form keyways for roof, floor and the side walls of the Intake Valve House.

(m) Measurement and Payment. - Concrete work in the dam shall be measured by the cubic yard in place. Measurement shall be made to the neat lines as established by the forms and the sound rock as shown by the drawings or as ordered by the Engineer. The measurement shall include only the net volume of concrete within the required lines of the structure and the volume of the penstock and the vent pipe shall not be included. Payment for concrete shall be made at the contract unit prices, per cubic yard. The Contract unit price shall include the entire costs of all labor, equipment, transportation, and all materials except as detailed in Par. (b) above. No payment shall be made for concrete wasted, lost or rejected for improper mix.

ITEM #14. CONCRETE IN APRON

(a) General. - The apron below the spillway shall be formed with (3000#) concrete poured in blocks as shown and 3'-0" thick. Reinforcement, including the anchor dowels and 1" round deformed bars, twelve inches on centers both ways, set 6 inches below the top surface of the blocks will be furnished, set and wired under Item #19 Reinforcing Steel.

(b) Specifications. - All specifications in Section III Concrete Work, General shall be considered as a part of the specifications for this Item #14 so far as the same may apply.

(c) Joints. - An approved 1/2" molded asphalt joint material shall be placed between each block, the full thickness of the block but kept 1/2" below the top and this joint shall be filled with an approved hot asphalt joint filler.

(d) Grouting Dowels. - The anchor dowels will be furnished and set under Item #19 Reinforcing Steel. Under this Item #14, the Contractor shall grout in the dowels at least 24 hours before the apron concrete is poured.

(e) Finish. - The top surface of the concrete apron shall conform to the drawings, shall be tamped to force all coarse aggregate below the surface and shall be finished to a smooth surface under wood floats.

(f) Measurement and Payment. - Concrete work in the apron shall be measured by the cubic yard in place. Measurement shall be to the neat lines shown on the drawings or as established by the Engineer.

Payment shall be made at the contract unit price which shall include the entire costs of all labor, equipment, transportation, and all materials except portland cement, and steel reinforcing.

ITEM #15. CONCRETE IN WEIR

(a) General. - The weir below the stilling pool shall be formed of (3000#) concrete over the prepared surface of the ledge and formed as shown. All exposed surfaces shall have all coarse aggregate pushed well back from the surface and be well troweled to a smooth surface under wood floats.

(b) Not Included. - The Weir Gate and the Iron Work in the Weir will be furnished and delivered on the site under other Contract Items but shall be set in place under this Item #15.

(c) Specifications. - All specifications in Section III Concrete Work, General shall be considered as a part of the specifications for this Item #15 so far as the same may apply.

(d) Measurement and Payment. - Concrete work in the weir shall be measured by the cubic yards in place to the neat lines shown on the drawings or established by the Engineer.

Payment shall be made at the contract unit price which shall include all costs in connection with this work, except Portland cement, reinforcement and the weir gate.

ITEM #16. CONCRETE WORK IN INTAKE VALVE HOUSE AND OUTLET VALVE HOUSE

(a) General. - All foundations, walls, floors and roofs shall be formed of (3000#) concrete poured in place in accordance with all the details as shown. All steel reinforcing, iron work and Miscellaneous Piping are furnished and set under the respective contract items, and under this Item #16, the Contractor shall check for correct position and shall build them into the concrete.

(b) Not Included. - Reinforcing steel is specified under Item #19, and iron work under Item #23. Miscellaneous Piping under Item #21, cement is included under Item #13.

(c) Specifications. - All specifications in Section III Concrete Work, General shall be considered as a part of the specifications for this Item #16 so far as the same may apply.

Especial attention shall be given to make all concrete work below the operating floors as dense and impervious as possible.

(d) Windows. - Sills should be precast and set in place in cement mortar. Form rabbets in jambs and heads of windows in which the steel sash shall be later set.

(e) Construction Joints. - Form keyways and slots in dam construction for the roofs, walls of the valve houses as shown. Steel reinforcing shall be continuous through these joints.

(f) Building In. - The Intake Valve and the Outlet Valve, the penstock and discharge pipe will be erected under other Contract Items and under this item the Contractor shall build them into the concrete work, removing all temporary supports and bases.

(g) The Contractor shall set and rigidly secure in place all anchor bolts for equipment, all built in anchors, all iron door frames, and all other miscellaneous iron work which is to be built into the concrete work.

(h) Floor Finish. - All floor surfaces shall have an integral floor finish as specified under Section III Concrete Work, General.

(i) Measurement and Payment. - Measurement of concrete for payment shall be made to the required neat lines of the structures. Measurement shall include only the actual net volume of concrete within the required lines of the structure and the volume of all openings, embedded penstock or discharge pipe shall be deducted.

Payment for concrete shall be made at the contract unit price per cubic yard for this Item and shall include all costs of labor, equipment, transportation and all materials except as above specified.

ITEM #17. CONCRETE IN RETAINING WALLS

(a) General. - The retaining walls between the two valve houses and below the outlet gate house shall be built of 3000# concrete as shown on the drawings or as directed by the Engineer.

(b) Not Included. - Cement, steel reinforcing.

(c) Specifications. - All specifications in Section III Concrete Work, General, shall be considered as a part of the specifications for this item so far as the same may apply.

(d) Measurement and Payment. - Concrete work in the retaining walls shall be measured by the cubic yards in place to the neat lines shown on the drawings or established by the Engineer.

Payment shall be made at the contract unit price per cubic yard which shall include all costs in connection with this Item except portland cement and reinforcement.

ITEM #18. PORTLAND CEMENT

(a) Includes the furnishing and delivery at the site of the quality herein specified in sufficient quantity and at the times needed for the entire concrete work and cement grouting.

(b) Cement. - All specifications in Section III Concrete Work, General, applying to portland cement shall be considered

a part of the specifications for this item so far as the same may apply.

(c) Reports. - The Contractor shall furnish to the Engineer, at the end of each days work, a detailed statement showing in such detail as he may reasonably require the quantity of cement used during each day in each part of the work.

(d) Payment. - The quantity of cement to be paid for under this Item #18 shall be the number of barrels (barrel equal to 4 bags or 94 lbs. each) used, in all parts of the work unless specifically excepted. Payment shall be made at the contract unit price which shall include all costs incidental to the purchase and delivery of the cement at the site.

No payment shall be made for cement not incorporated in the work, nor for any cement used in concrete or grout that is wasted or rejected.

ITEM #19. REINFORCING STEEL

(a) Scope. - Includes the furnishing, delivery and installation of all reinforcing steel for the entire work included in all of the contract Items in which reinforcing steel is used, as shown on the drawings, listed in the specifications and as reasonably implied by either or both. Includes the anchor dowels in the concrete apron.

(b) Steel Reinforcing. - Shall be intermediate grade, conforming to the requirements of the specifications for Billet-Steel Bars for Concrete Reinforcement, A.S.T.M. A-15, shall be deformed bars of type approved by the Engineer, free from flaking, rust, loose scale or coatings of any kind which would reduce or destroy the bond.

(c) General. - This Contractor shall furnish, cut, bend and place all steel reinforcement as indicated on the drawings or herein specified. Reinforcing shall be bent and placed in exact positions as shown on the drawings.

(d) Reinforcement. - May be mill or field bent and shall not be bent or straightened in a manner to injure the metal. Cold bars shall bend around a pin of not less than 6 diameters of the least dimension of the bar. Deformed bars shall develop a bond strength at least 25% greater than that of a plain round bar of equal cross section. Bars with kinks or bends not required by the drawings shall not be used. All splices and crossings shall be securely wired with not less than #16 gage malleable steel wire. Reinforcement shall at all times be satisfactorily protected from moisture until placed in final position. Ends of rods that may be left projecting for a considerable time shall be painted with a heavy coat of cement grout.

(e) Supports. - All reinforcement shall be supported above the forms as shown by the use of concrete briquettes, metal supports, spacers or ties as approved by the Engineer. Metal chairs shall not be used where they would show or be near the under side of exposed beams or slabs. Supports shall be of sufficient strength to maintain the reinforcement in place throughout the concreting operation and shall be used in such a manner that they will not be exposed on the face of, nor in any way discolor the surface nor be noticeable in the surface of exposed concrete.

(f) Splicing. - Where splices in reinforcement, in addition to those indicated, are necessary, there shall be sufficient lap to transfer the stress. Rods shall be lapped not less than 40 diameters and splices shall be staggered. The lapped ends of rods shall be separated sufficiently or connected properly to develop the full strength of the rod.

(g) Cleaning. - All reinforcement shall be when concrete is placed, entirely free from moisture, rust, scale, grease or other coating which might destroy or reduce its bond with the concrete.

(h) Payment. - Payment shall be made for all reinforcing bars used in the work at the contract unit price per pound. Quantity shall be based on the actual weight of the bars and shall not include chairs, ties, wire or other devices.

Contract unit price per pound shall include all costs in connection with the furnishing, placing and wiring of all reinforcing in position.

ITEM #20. STEEL PIPE

(a) Scope. - Furnish and install in position previous to the pouring of the enclosing concrete all steel pipe for grouting in the structure of the dam, of sizes as shown and with all connections, removable members, and fittings including the headers connecting the grout pipes. Work shall include the connection of the grout pipes into the vertical joints. Include pipe to be used if ledge is grouted.

(b) Pipe. - Shall be mild steel Schedule 40 with cast or malleable iron fittings.

(c) Completion. - After grouting is completed, the removable sections of pipe shall be removed, and all header piping removed.

(d) Measurement and Payment. - Payment for steel pipe shall be based on the weight of pipe actually installed on the work in accordance with the drawings or as directed and the contract unit price per pound shall include all materials required and all labor to install all pipe and fittings and to remove all pipe indicated as removable and the pipe used in

SECTION V

THE DIKE

DESCRIPTION. - The dike shall be of earth with a top width of 20 feet and a top length of about 200 feet and a maximum height above the present surface of approximately 20 feet. The core shall be carried to an impervious material about 11 feet below present surface and shall be constructed of impervious material obtained in the general vicinity of the dike location.

Item #33. STRIPPING

(a) Before the excavation for the core trench is started the Contractor shall remove from the entire area under the embankment location and satisfactorily dispose of all top soil, peat, silt, muck, loose rock, highly organic or other unsatisfactory materials to the depths directed. Stripping shall be extended only to the depths from the original surface as are directed and as necessary to remove all unsatisfactory materials. No stripping of borrow areas or other areas outside the area under the embankment shall be included under this item, even though stripping may be needed to render the underlying materials acceptable for fill.

(b) All grubbing of stumps and roots in the area under the dike and to a distance of 25 feet easterly and westerly from the toes of the embankment shall be included in this item.

(c) The site of the dike and areas easterly and westerly from the dike are, in general, covered with a top layer of about 30 in. thick of relatively impervious material underlaid by a layer of more pervious material. The layer of impervious material shall not be cut into in the stripping operations under the dike beyond that necessary to remove any unsatisfactory materials, except where excavation is required for the core trench.

(d) The impervious material shall not be disturbed on the pond side of the dike and shall not be disturbed on the easterly side of the dike for a distance of about 200 feet from the toe of the dike. Any materials removed from these areas shall be replaced with compacted impervious material to the original grades.

(e) Disposal. - The Contractor may use suitable and approved stripped material, to the extent as directed, in the construction of the embankment. All unsatisfactory materials shall be wasted to spoil banks in prescribed lines and grades in designated locations between the dike and the town road. Trees, stumps, roots and other burnable materials shall be burned or otherwise satisfactorily disposed of.

(b) Payment. - Payment shall be made at the contract [illegible] per cubic yard for the number of cubic yards removed [illegible] satisfactorily disposed of in accordance with orders, [illegible] excavation. [illegible] stipulated [illegible] and roots in [illegible] to a distance of [illegible] outside the toes of [illegible], the refill of impervious materials as specified [illegible] (c) [illegible] item, and for the disposal of all materials [illegible] in the embankment. [illegible] measurement for payment shall [illegible] materials re-excavated from temporary [illegible] materials excavated from borrow pits or from [illegible], nor shall it be permitted to be stripped for [illegible] materials.

Item #34. EXCAVATION

(a) Excavation for the core shall be carried to impervious material which in general is about 11 feet below the present surface. The materials through which the excavation is to be carried consists of about 30 inches of top soil and 8'-6" of glacial till. The trench shall have a width at the bottom of about two feet with side slopes of about one on one. Materials removed which are suitable may be stored in piles and used in the embankment of the dike.

(b) Measurement and Payment. - The quantities which shall be paid for under this item shall be the number of cubic yards excavated and satisfactorily disposed of in accordance with the drawings or as ordered, measured as specified in place before excavation.

The measurement for payment shall not include materials excavated from borrow pits, nor materials excavated for Contractors' roads, camps, drains, nor for other temporary or construction purposes, nor materials re-excavated from storage piles, nor materials excavated by permission outside ordered limits. Neither shall it include any rehandling of materials in the construction of the dike nor any excavation of embankment material even though such excavation may be necessary or required for the proper trimming and grading of slopes.

Payment shall be made at the contract unit price per cubic yard under Item #34 and shall include all costs involved in the specified work. It shall include all costs of the disposal of all excavated materials which are not suitable for use in the embankment.

Item #35. EMBANKMENT

(a) Work to be Done. - Under this item the Contractor shall furnish, transport, place, grade and consolidate acceptable materials, within the limits shown on the plans or ordered, in the refill of the core trench, in the embankment of the dike inside the stone fills and beneath the riprap, including the refill of volumes under the dike stripped under Item #33, and any other ordered refill and embankment work adjacent to the dam except those specifically ordered under other items.

... - ... classes of materials will be re-
... this item, and in general each class of
... satisfactorily fulfill the specific purposes for

... - ... trench
... shall ... of suitable
... impervious quality. Acceptable and
... -soils obtained from the stripping
... reasonably free from vegetation, masses
... materials. ... material
... from approved borrow pits.
... - ... within the
... and, between the core and the
... usually be glacial till of a more
... materials used in the core. The
... these locations may vary from rela-
... pervious materials, to coarse, free-
... materials, and although there is a wide range
... in general the Engineer will, as far as
practicable, require the more impervious placed adjacent to the core, or in other suitable locations, and the coarser pervious placed adjacent to the toes and faces. Suitable materials from the required excavations may be used, and the remainder may be obtained from approved borrow pits. Materials placed in the toes and faces of the dike shall consist of the coarsest, most pervious, free-draining materials available in the vicinity of the work.

(2) Pervious Materials under Downstream Shoulders of Dike. - The surface of the soil exposed in excavation and stripping operations under the embankment shall be covered with a layer of pervious materials between the easterly limits of the core and the easterly toe of the embankment as shown on the plans or ordered. The pervious materials shall consist of selected sand and gravel, placed under the direction of the Engineer with the sand next to the core, grading into gravel toward the toe of the dam as indicated on the plans. The gravel shall consist of coarse sand and small stones as obtained from selected borrow pits.

(c) Placing. - The embankment of the dike shall be started on a base which shall have been stripped and grubbed to the extent ordered under item #33, and which shall have been rolled to the extent ordered for firmness. Materials placed shall, unless otherwise permitted or required, be deposited in horizontal layers and thoroughly compacted by rolling. The core and embankment materials shall be rolled in layers 6 inches thick after rolling, unless sheepsfoot rollers are used having 7 in. teeth, in which case the layers may be 8 in. thick after rolling. In general, the embankment work shall be carried on in such manner that the core construction is maintained about 2 feet higher than work on adjacent shoulders, allowing drainage of water from the surface of the core freely.

(d) Moisture Content. - Materials placed, unless sufficiently [illegible] shall be wetted to the extent directed. [illegible] to the [illegible] is to be so placed that no wetting [illegible]. If, however, in the opinion of the Engineer, [illegible] of the materials coming from the borrow pits [illegible] easily [illegible] to obtain the proper consolidation, [illegible] shall be drained or otherwise dry [illegible] to render the materials borrowed satisfactory, [illegible] the borrow operations to make satisfactory [illegible]. Proper consolidation can probably be obtained with [illegible] of from 10 to 20 percent of the dry weight of the material for impervious material, and from 10 to 15 percent for [illegible] materials.

(e) Compaction. - Material placed shall be rolled as directed, with an approved roller, either of the sheepsfoot type weighted as required, or of a self-propelled, banded, three wheel type, weighing not less than 10 tons, the resulting pressure under the rear wheels of which shall not be less than 500 pounds per inch width of wheel. The roller shall pass over every part of each layer that can be traversed by it, and the number of trips required for satisfactory consolidation for each type of material will be specified by the Engineer as the work progresses. The number of trips required will probably be more than six but less than ten.

(f) Tamping. - Portions of refills or embankment which the rollers cannot reach for any reason shall be compacted by tamping manually with extra heavy tampers used energetically, or by other means which will secure a degree of compaction equal to that obtained by rolling as specified. Where manual tamping is required, the material shall be placed and compacted in layers 3 inches thick after tamping impervious portions of embankment, and in layers 4 or 5 inches thick for other portions. No work shall be done on the placing of the rolled refill or embankment during periods of freezing weather, or at other times or periods when, in the opinion of the Engineer, the weather is such as to interfere with proper construction. No frozen material shall be used in the construction of rolled earth fills, nor shall materials be dumped upon foundations or fills which contain frost.

(g) Payment. - The quantities to be paid for under this Item #35 shall be the number of cubic yards placed in accordance with orders, measured in position after compacting. The contract price stipulated per cubic yard under Item #35 shall include all costs for preparing the base except for such grubbing and stripping as may be ordered under Item #33; borrowing, transporting and placing of materials; spreading in layers, wetting, rolling, tamping, trimming to line; and all labor and materials incidental to satisfactorily completing the embankments of the dike. The measurement for payment shall not

[illegible] backfilling of unauthorized excavations, [illegible] placed outside the prescribed lines even though [illegible] may have been placed with the permission or [illegible] Engineer immediately adjacent to or [illegible] of [illegible] for the Contractor's plant, camp, [illegible] requirements in carrying out the provisions of this contract.

Item [illegible]. [illegible] AND STONE FILLS

[illegible]. - The Contractor shall furnish all [illegible] and place stone fills to construct, within the [illegible] or as directed, the riprap on the [illegible] only [illegible] of the dike embankment, and the [illegible] to the easterly and westerly toes of the dike, to the [illegible] and over the areas as shown on the drawings.

(b) Material. - Riprap and stone fills shall be composed of durable stone of approved sizes. Rock, boulders and large cobbles from the excavation from the core trench approved by the Engineer and suitable boulders and large cobbles from the borrow pits, may be used in the construction. Additional stone of approved sizes and quality for any part or parts of this stonework construction to fulfill any deficiency of approved excavated work required to complete the stone fill requirements as shown on the drawings or as directed shall be furnished by this Contractor from other sources.

(c) Riprap. - On the westerly face of the dike shall consist of such sizes that for any volume of 50 cu. yds. or more at least 20 percent shall be larger than one cu. ft; at least 50 percent larger than 1/2 cu. ft. and all stone shall be larger than a 3-inch ring size. Riprap on the easterly face shall have no broken stone or gravel which will pass a 2-inch ring and at least 50 percent of any volume of 50 cu. yds. or more shall be stones exceeding 4-in. in diameter size, and at least 20 percent exceeding 6-in. average diameter size. The stone required for the stone fills shall be satisfactorily free from rock flour, silt and muck and shall not contain excess quantities of chips and finely broken rock fragments. All riprap and stone fills shall contain a sufficient number of angular stones to give stability to each entire mass.

(d) Placing. - The Contractor will not be required to place riprap or stone fills by hand except to rearrange surface stones as required to fill unsatisfactory depressions in the surfaces below the established surface grades. The average surfaces shall satisfactorily approximate the required theoretical.

(e) Measurement and Payment. - The quantity which shall be paid for under this item shall be the number of cubic yards

[illegible] satorily placed in the completed work, measured by the [illegible] thickness for each indicated change in thickness and by [illegible] covered, and to the ordered theoretical surfaces, [illegible] of the quantities of riprap or stone fills project- [illegible] such surfaces and with no deductions for voids. [illegible] at the contract unit price stipulated [illegible] Item 610 and the price stated in the contract shall include cost of all work directly or indirectly connected with furnishing, placing and trimming the riprap and/or stone fills.

BOSTON

Feb. 27, 1948

[illegible],

[illegible]

[illegible] River Project - [illegible]

[illegible]:

I submit the following final report upon the Green River Project of the Village of Morrisville, Vermont, which was substantially completed on October 15, 1947.

Appended for your convenience is a copy of the portion of my report to your Commission, dated Dec. 11, 1945, which includes a detailed description of this project and my preliminary recommendations as to its advisability and safety.

Construction of this project began in April 1946. Following are extracts from my notes taken during visits subsequent to that time. On Fig. 1 appended are shown dates and location of concrete pours for the dam.

(1) Aug. 29, 1946: Present Mr. Bernard S. Rose of Chas. T. Main, Inc., Supt. J. M. Moore for the contractors, - O. W. Miller & Co. - Supt. [illegible]. K. Sanders of the Village Power & Light Department and A. H. Millett, Resident Engineer - 9-11 A. M.

Dike completed - a good looking job

about 125 acres cleared out of 600

Rock excavation at dam nearly completed. A low sand bag coffer dam in place with 6" pump confining flow to a 15 ft. channel next the right shore.

A small amount of concrete in place at about El. 1200 - up on left bank.

Ledge rock or schist - a good foundation. Stone and sand on hand, coming from Johnson's pit. Tests by State Highway Dept. showed good materials. Tests of fine aggregate were also made by Thompson & Lightner of Boston, and reported June 11, 1945, which were satisfactory. About 25 men at work on average.

(2) Oct. 8, 1946 - Sanders, Millet and Moore - 9:30 - 11:30 A. M. Pouring concrete in bottom section adjacent to intake about a 270 c. y. section.

Concrete mixer at top of slope on left bank - concrete dropped in a chute to near lower level where handled by 2 - 3/4 c.y. buckets (used alternately) and derrick.

Time of bucket one trip = 1 3/4 min.

Mixture 1-2-3 (6.0 bags cement per c. y.); using vibrator occasionally near ends of section.

Time of mixing concrete (measured) 1 1/4 min. - (2/3 c.y. batch)

Little leakage through coffer dam.

Stone coming rather sandy - too much fine material. Millet to improve this and get cleaner, larger stone

(This was done)

Placing work well under way. W. S. at dam El. 1125; in pool above, El. 1126.

(2) [illegible] Sanders, Millet and Moore - 8:30 A. M.

Concrete being poured in Section 26 and 27 at stations 205 to 245. (See Fig. 1).

Timing of concrete delivery viz. time for 1 1/4 c. y. skips of concrete to be filled, carried by derrick to receiving platform, unhook, pick up empty skip and return to starting place.

Time of Day	Time Min.	
9:44 A. M.		
9:46 "	2	
9:48 1/4 A. M.	2 1/4	Average time 2 1/4 min. or
9:50 1/2 "	2 1/4	about 25 c. y. ? hr. while
9:52 1/4 "	1 3/4	working.

Rate of placing concrete is fixed at mixer, including placing materials in mixer plus 1 min. minimum time of mixing. About 25 c. y. ? hour while working.

Exposed new concrete faces look good.

May. 21, 1947 Sanders, Millet and Moore - 9:30 - 11 A.M.

Concrete being poured near west end 2 + 45 to 2 + 85 between El. 201 and 209.

This was handled by chute from mixer, received in 1 1/4 c. y. Buckets carried across a temporary wooden bridge and placed by portable derrick with 60 ft. boom upon w. end of bridge.

Pouring now alternating between the west end of dam, as noted above, and 2 corresponding sections at east end, where the derrick handles buckets directly from end of chute.

Mixing of concrete - at receiving end.

Time of Batch	Note		Elapsed time between buckets
10:24	Bucket full & taken by truck	1	
10:[illegible]	Back again		2:5 min.
10:[illegible]	Concrete [illegible] coming		
10:[illegible]	Bucket taken by truck again	2	
10:[illegible]	Back again		4:5 min.
10:[illegible] 1/4	Concrete coming in again		
10:31	Bucket taken by truck again	3	
10:31 3/4	Back again		2:0 min.
10:33	Bucket taken by truck again	4	

At mixer

Noted time of mixing by observing time when new batch started down chute.

Times = 11:45 to 11:50 - 5 min. - 2 batches or 2 1/2 min. per batch.

(Note that minimum allowable time by specifications is 1 1/2 min.)

Winter work No concrete poured in dam proper between Dec. 14 and April 24.

During January for about a week poured 200 c. y.± in apron.

Since April 24 have alternated pours upon or near each end of dam - total since then about 1400 c. y. to date.

Present condition (May 21)

Station	Poured to Elevation	Remarks
0+00		East end of dam
	1225	Top of dam
0+85		
	1209	
1+25		
	[illegible]	(Poured Dec. 15)
2+[illegible]		
	1201	(Poured to 1209 - May 21)
2+85		
	1193	[illegible]

[illegible] Sanders and Moore - 9:00 - 10:30 A. M.

[illegible] - between sta. 2 + 05 to 2 + 45

[illegible]

[illegible] 2 + 91 to El. 2. 3
[illegible] to 2 + 0. to [illegible] millway
[illegible] to 2 + [illegible] to 1. [illegible]
[illegible] to 1. [illegible]
[illegible] to 1. [illegible]

Poured - [illegible] to [illegible] c. y.
[illegible] to [illegible] c. y. (out of 10,000f)
[illegible] closely 2/3 cu. yds.

[illegible] June 18th

Now 40 ft. of water or to El. 1139.54 - about 80 mill. cu. ft. - (out of 700 mill. cu. ft.)

Joints now grouted about 1/2 way up (100 #□" pressure)

Time of Mix 9:50 / 9:52 A. M. or 2 minutes - O. K.

Slump Tests made once weekly

Cylinder compression tests - 2 cyl. for every other pour made & stored at plant - shipped to Puffer for tests.

Aug. 21, 1947 Sanders and Moore - 9 - 10:15 A. M.

Water in reservoir El. 1176.

Began drawing off Aug. 9 at El. 1178 - about 50 cfs. flow. Draw 5 - 7 P. M. - takes 10 hours to get to Morrisville. Adds about 300 kw. to pour.

Concrete completed on main dam - 5 vertical joints remaining to be grouted.

Stilling pond weir nearly done - 75 ft. long El. 1139, El. 1127.5 at base.

30" outflow pipe and hand operated valve at El. 1135, or submerged 4 ft.

[illegible] and Millet - [illegible] - 10:20 A. M.

[illegible] - between sta. 2 + 05 to 2 + 45

[illegible]

[illegible] to El. [illegible]
[illegible] to [illegible] millway
[illegible] to El. [illegible]
[illegible] to El. [illegible]
[illegible] to El. [illegible]

Poured - [illegible] to date [illegible] C. Y.
[illegible] to date [illegible] C. Y. (out of 10,000)
[illegible] already 2/3 cu. yds.

[illegible] June 16th

Now 40 ft. of water or to El. 1139.5± - about 50 mill. cu. ft. - (out of 700 mill. cu. ft.)

Joints now grouted about 1/2 way up (100 #□" pressure)

Time of Mix 9:50 / 9:52 A. M. or 2 minutes - O. K.

Slump Tests made once weekly

Cylinder compression tests - 2 cyl. for every other pour made & stored at plant - shipped to Puffer for tests.

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Water in reservoir El. 1176.

Began drawing off Aug. 9 at El. 1178 - about 50 cfs. flow. Draw 5 - 7 P. M. - takes 10 hours to get to Morrisville. Adds about 300 kw. to pour.

Concrete completed on main dam - 5 vertical joints remaining to be grouted.

Stilling pond weir nearly done - 75 ft. long El. 1139, El. 1127.5 at base.

30" outflow pipe and hand operated valve at El. 1135, or submerged 4 ft.

Starting & gate house

Final clearing of remaining worthless timber in reservoir under way.

Dam to be sprayed on upstream face with inertol, as water proofer.

Job nearly completed.

Oct. 6, 1947 - Spillway - 9 - 10 a. m.

Water 21. 1145 - fully drawndown owing to drought and need for water. Water very low.

All grout placing completed.

Inertol (black) has been sprayed on face of dam and inertol plastic trowelled into joints on back of dam.

Job substantially finished.

Cost to date Spillway about $200,000. - overrun of rock excavation and concrete.

Tests of concrete

All cement was tested at the mill (Lehigh & Iron Clad brands) and reported.

Slump tests to check consistency of concrete were made at first for each pour of concrete; later once per week.

Cylinder compression tests (6" diam. x 12" high) were made at the University of Vermont Testing Laboratory under the direction of Prof. L. A. Pfeiffer.

64 such tests were made between Sept. 1, 1943 and July 1947 and the results appended.

A diagram (Fig. 2) has also been made, giving results to date, and also noting the specification requirement of 3000 lbs. per sq. inch at 28 days.

A good check was thus kept upon strength and suitability of concrete.

Cost of Construction

The main contract for this work was with the C. W. Miller Co. of Ludlow, Mass. and included the dam, dike, setting of penstock, gate valves, etc. The steel penstock was supplied by Walsh's Holyoke Boiler Works and the gate valves by the Chapman Valve Co.

The total cost of construction of dam and reservoir, including engineering, was about $598,000.

Concluding

This project has been carefully designed and constructed in the best manner. The dam is, in my judgment, thoroughly safe and it is an attractive addition to Green River and its vicinity.

The construction cost of $598,000 is for the 700 million cubic feet of storage capacity about $790 per million cubic feet. This water will be used through a present total head (including Woods Falls plant nearly completed) of about 349 ft. or a cost of about $2.26 per mill. cu. ft. per foot of head.

A further power development below Green River Reservoir to Garfield, of about 560 feet of head in 2.2 miles is planned for future use of this water so that eventually about 900 feet of head upon the river will be utilized, going the cost per million cubic feet per ft. of head down to $0.88 which will be low cost storage.

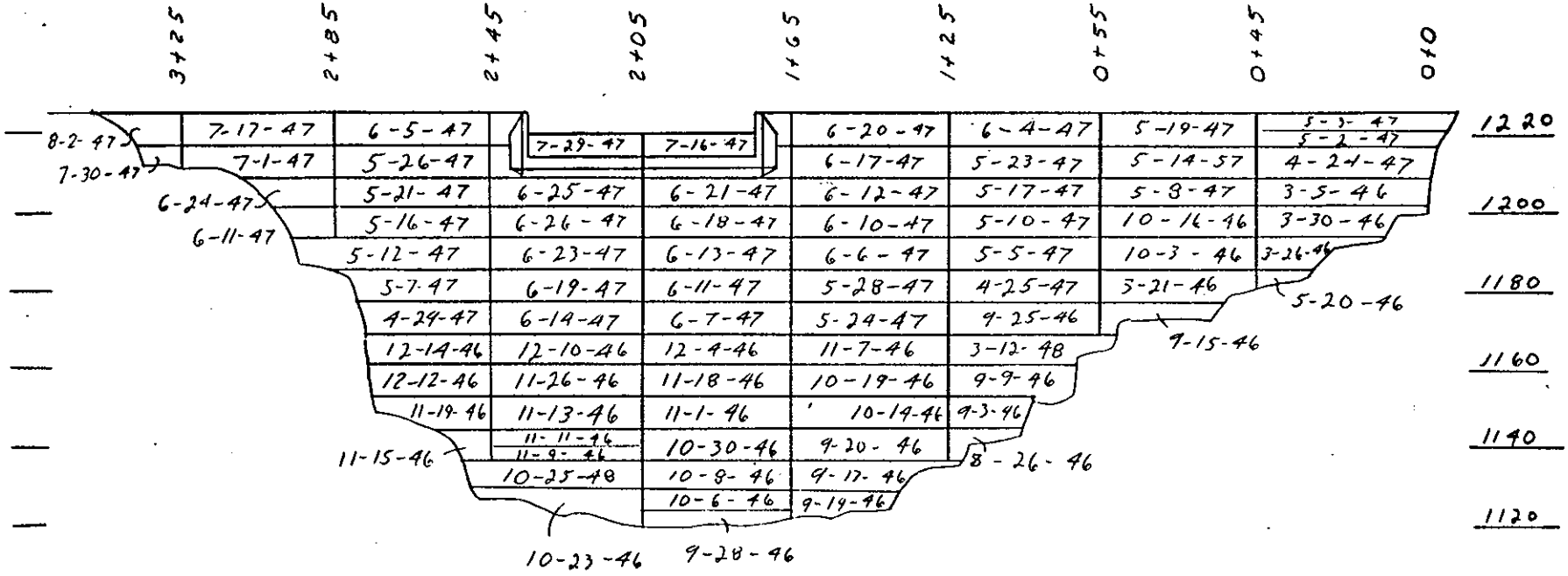
The Green River storage project is, in my judgment,

adequate for the public safety and a valuable and attractive addition to the power facilities of the Lamoille River Basin.

Appended are plans and other data, forming a part of this report.

Respectfully submitted,

H. K. Barrows



VILLAGE OF MORRISVILLE WATER AND LIGHT DEPARTMENT MORRISVILLE, VERMONT

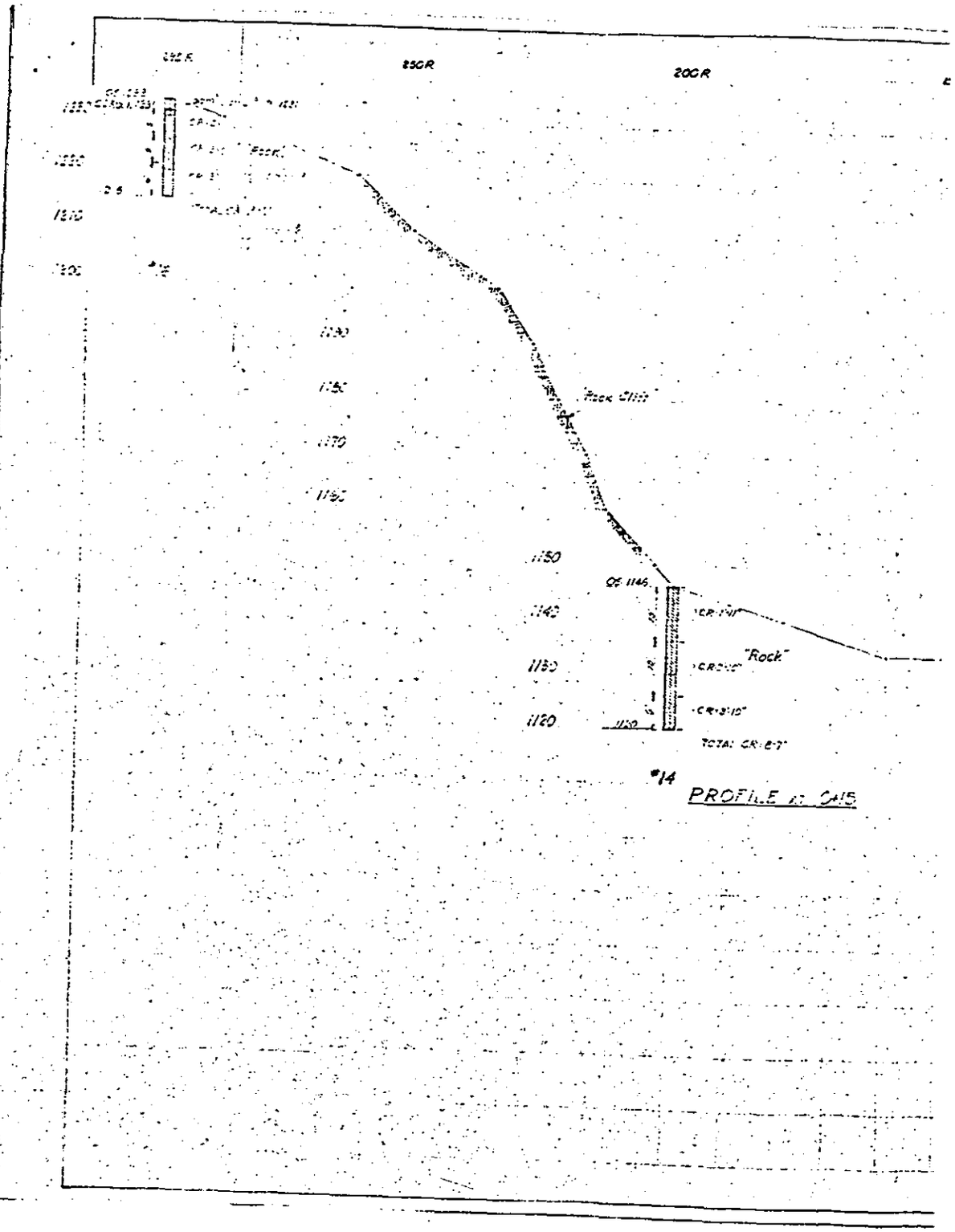
DATES OF CONCRETE POURS

CHAS T. MAIN, INC.
80 FEDERAL ST. BOSTON, MASS

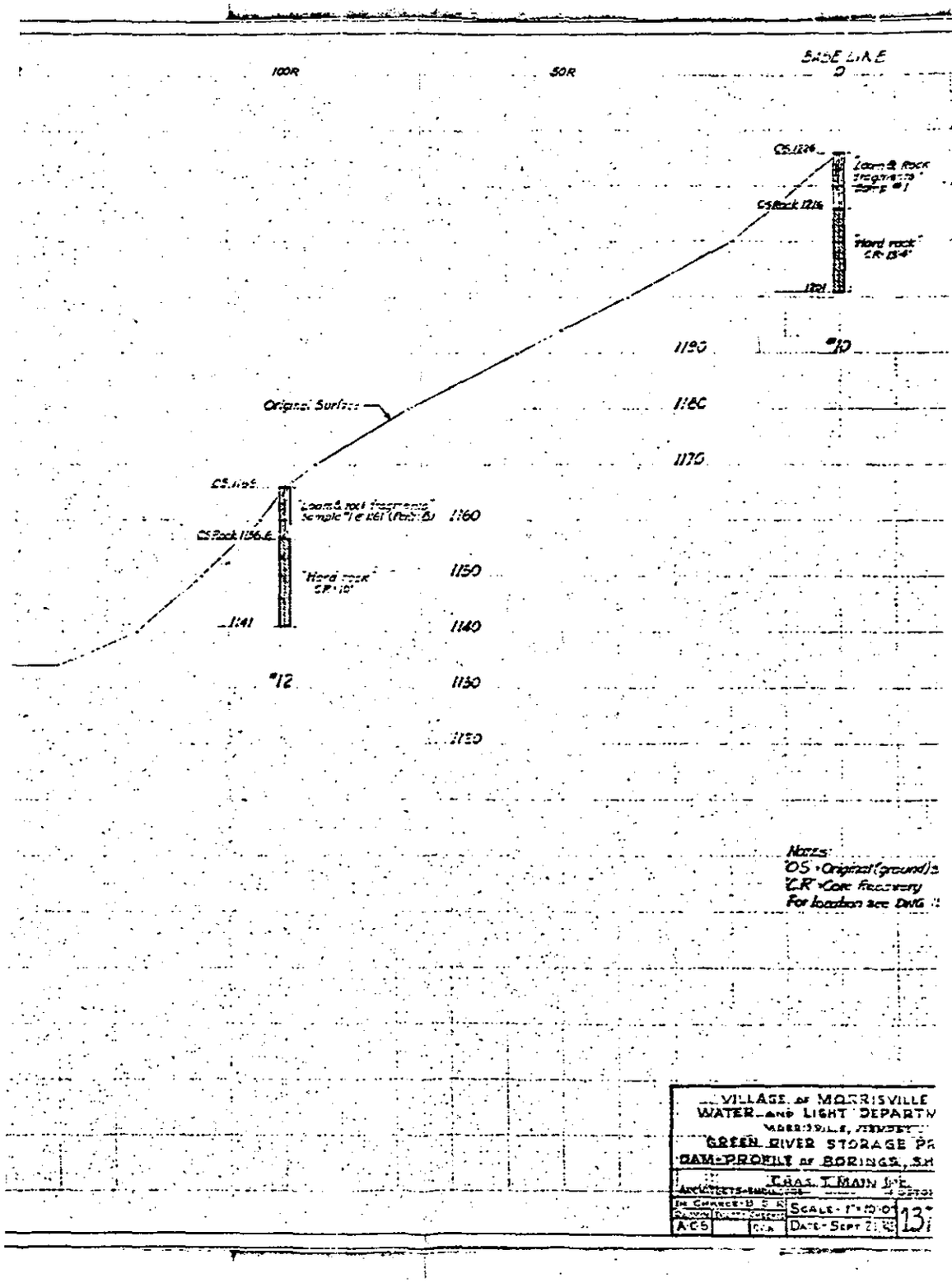
MCHARRIE D.S.R.		SCALE 1" = 10'
DRAWN	TRACE	
A.H.W.	S.G.F.	DATE 10-27-47

Date Made	Date Cored	Days	Pour	Lbs.	Remarks
1946					
Oct. 11		21		[illegible]	
[illegible]		20	13	[illegible]	Poor cyl. - one end bad
[illegible]		23	14	[illegible]	
Sep. 25		19	14	[illegible]	
Sep. 28		16	15	[illegible]	
Oct. 3		14	16	1997	Very poor cyl.
		28	16	3405	
Oct. 8		9	18	2610	
		28	18	3643	
Oct. 14		14	19	1846	Most of stones pulled out
		28	19	3636	
Oct. 16		14	20	2150	
		28	20	3537	
Oct. 19		14	21	1963	Ends not parallel - failed first at one side
		28	21	3579	Good
Oct. 23		12	22	2155	Good cyl.
Nov. 18		17	31	1917	
Nov. 19		16	32	2037	
19 Nov. 26		9	33	1556	
1947					
Apr. 24	June 5	43	38	3667	
Apr. 25	do	42	39	5019	
Apr. 29	do	38	40	-	Defective cyl.
May 7	do	30	43	2971	
May 8	June 4	28	44	1210	Probably defective cyl.
do	June 5	29	44	2762	
May 14	do	23	47	3979	
May 19	do	18	50	2952	
May 21	do	[illegible]	[illegible]	[illegible]	
[illegible]	do	[illegible]	[illegible]	[illegible]	
11 May 24	do	13	53	1877	

Date Cast	Date Tested	Hour	Lbs. Per Sq. In.	Remarks
May 21	[illegible]	[illegible]	[illegible]	
[illegible] 31	[illegible]	[illegible]	[illegible]	
[illegible] 1	do	30	3[illegible]	
[illegible] 2	do	29	51	[illegible]
[illegible] 23	do	24	52	[illegible]
May 24	do	23	53	2819	Data not recorded - not fair size
May 26	do	31	54	3061	One end badly chipped
May 26	do	31	54	4062	
June 6	do	20	58	3705	
June 7	do	19	59	2419	
June 10	do	16	60	3303	
June 11	do	15	61&62	1793	Defective cylinder - test repeated
June 12	July 1	20	63	2830	
June 13	do	14	67	3135	
June 17	do	15	66	3154	
	Report made July 7			
June 6	July 3	27	58	4122	
June 7	July 5	28	59	2023	
June 19	July 3	14	68	3185	
June 20	July 3	13	69	3047	
June 21	July 5	14	70	1988	
	Report made July 15			
June 10	July 6	28	60	3296	
June 11	July 9	28	61&62	3162	
June 26	July 9	14	73	2423	
June 12	July 10	28	63	3755	
June 28	July 11	14	74	1446	
June 17	July 15	28	66	3354	
	Report made July 23			
June 18	July 22	34	67	2747	
June 19	do	33	68	3508	
June 20	do	32	69	3254	
June 21	do	31	70	3036	
July 1	do	22	75	2366	
	Report made July 30			
June 26	July 25	28	73	2633	
June 28	July 25	28	74	2652	
July 1	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible] 13	[illegible]	14	76	3076	
July 17	July 30	14	77	2271	

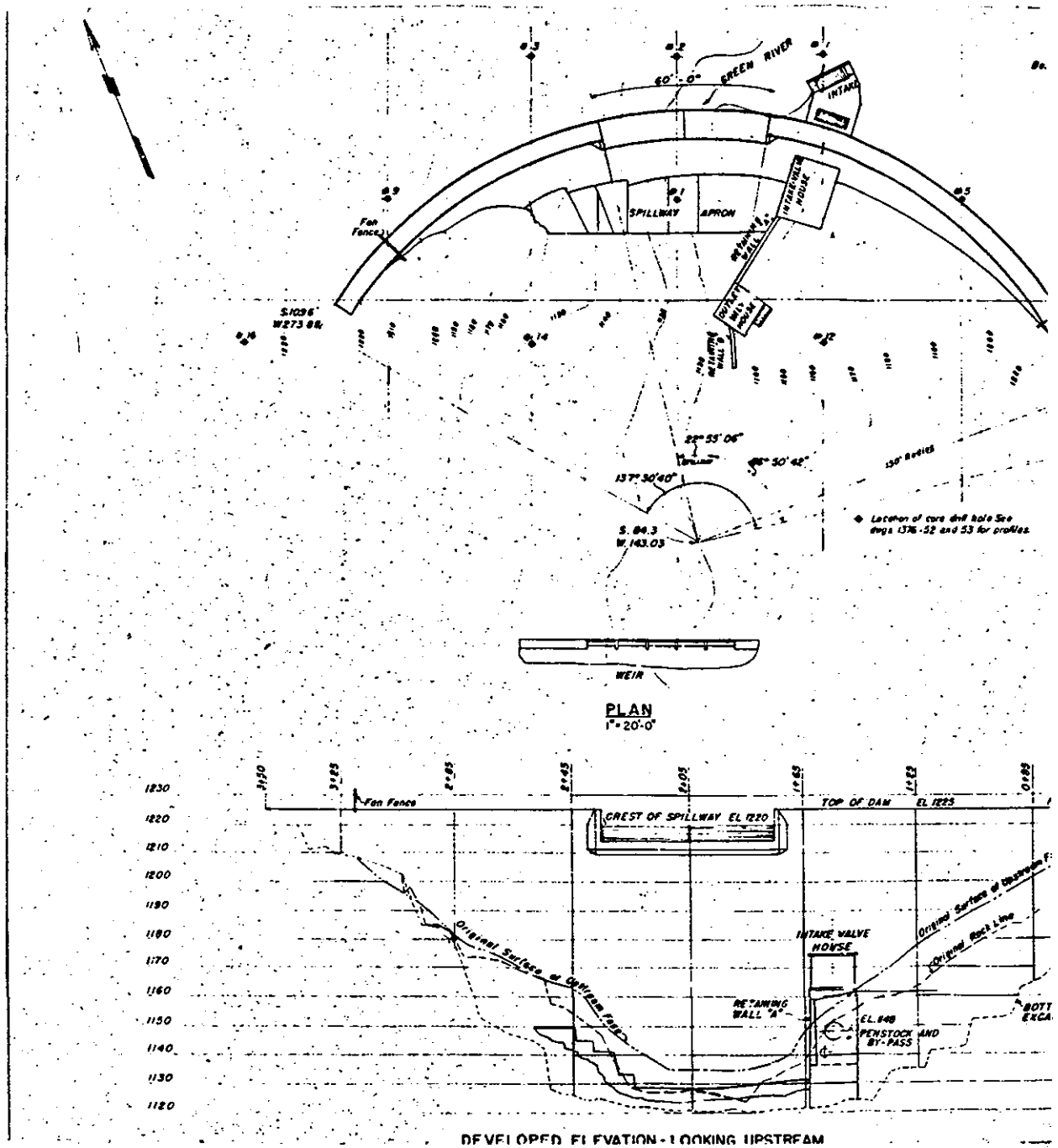


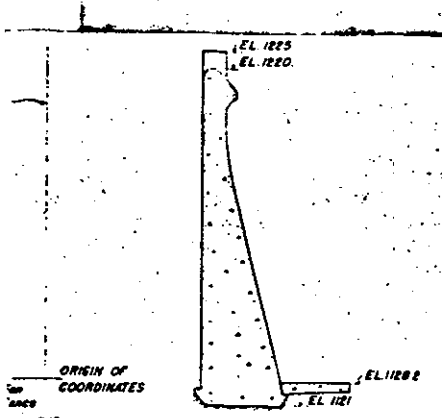
#14 PROFILE AT CAIS



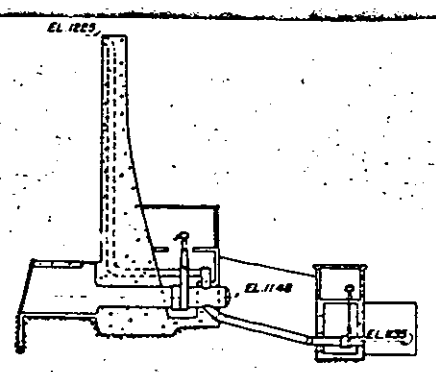
Notes:
"CS" = Original (ground) s
"CR" = Core Recovery
For location see DWG

VILLAGE OF MORRISVILLE
WATER AND LIGHT DEPARTM
MORRISVILLE, NEW YORK
GREEN RIVER STORAGE PR
DAM-PROFILE OF BORINGS, SH
THOS. T. MAIN INC.
ARCHITECTS-ENGINEERS
BOSTON
In Charge: E. R.
Scale: 1" = 10'-0"
Drawn: A.C.S.
Checked:
Date: Sept 2, 19
13

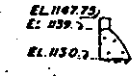




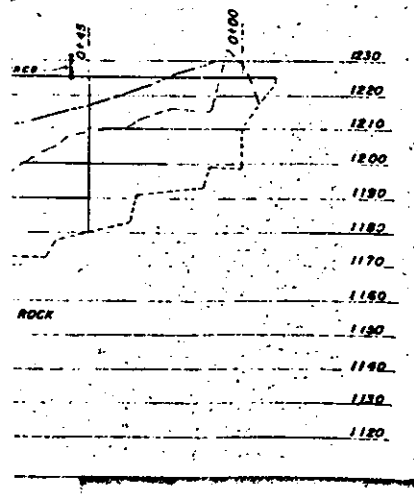
SECTION THRU SPILLWAY
1"=20'-0"

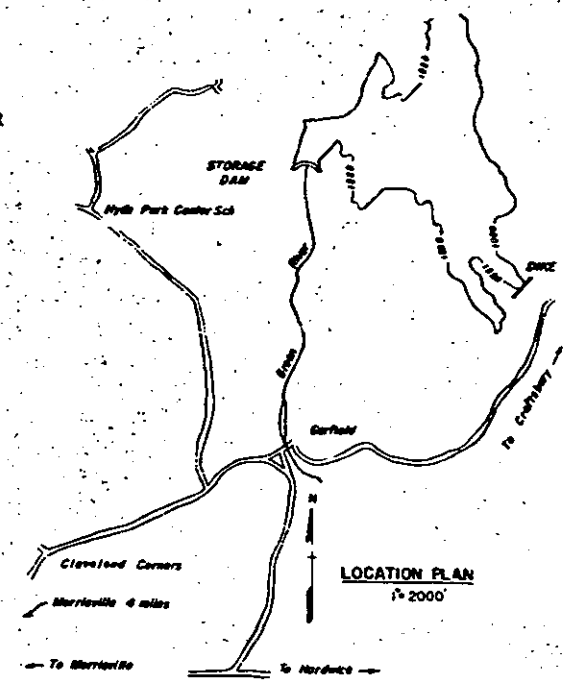


DEVELOPED SECTION ALONG ℄ PENSTOCK AND BY-PASS
1"=20'-0"



SECTION THRU WEIR
1"=20'-0"



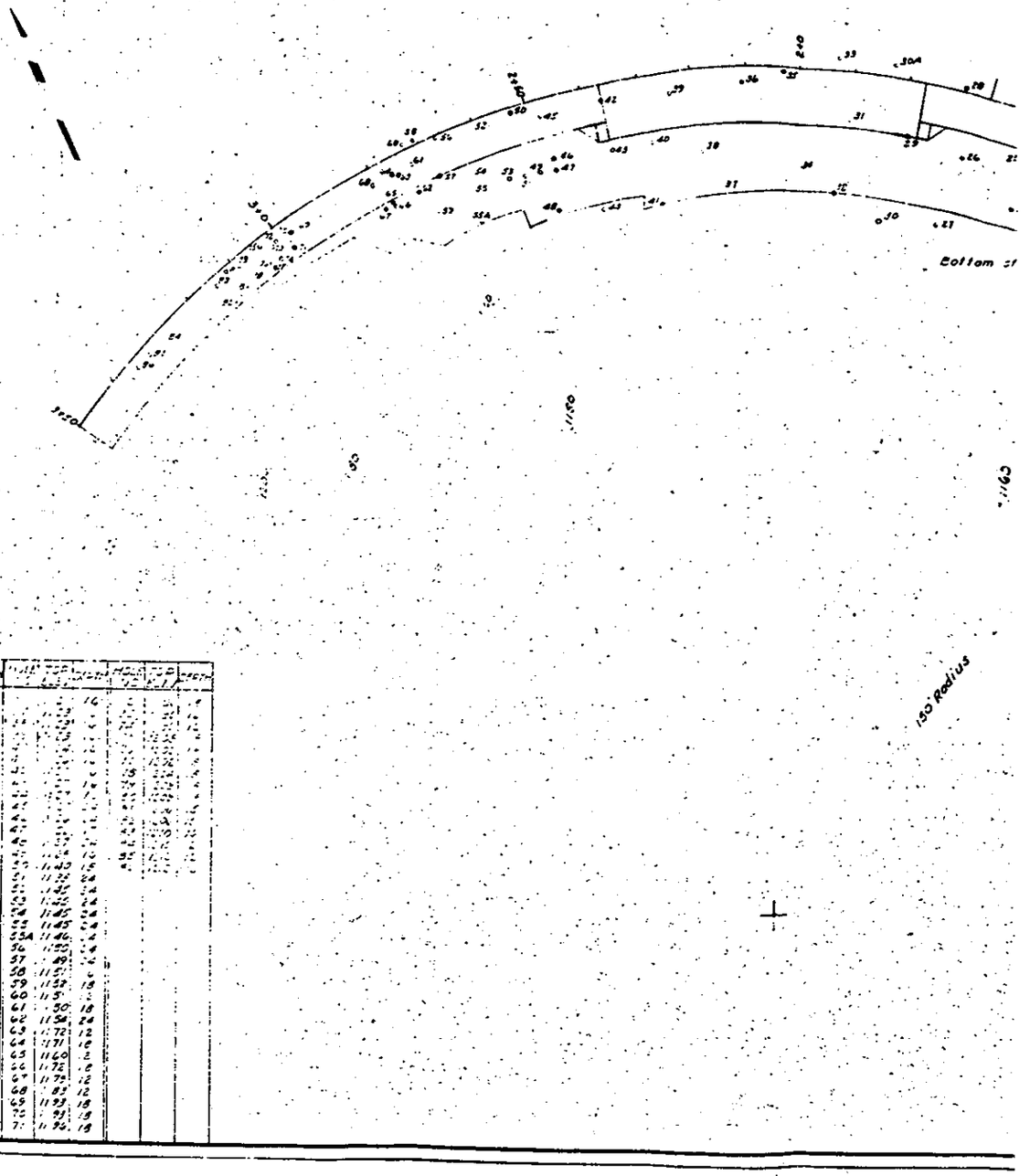


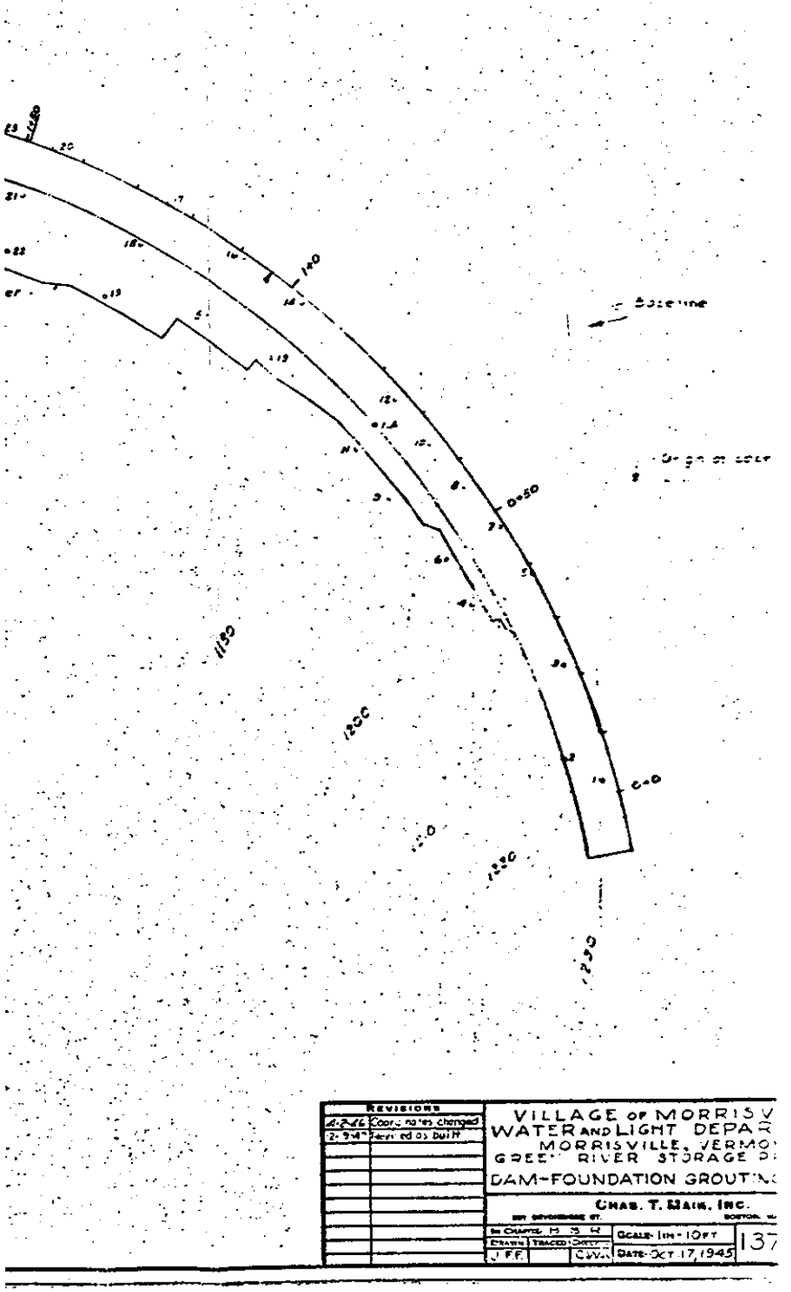
REVISIONS	
6-8-66	COORDINATES CHGD
12-6-67	ROCK LINER AND SPOIL AS BUILT

VILLAGE OF MORRISVILLE
WATER AND LIGHT DEPARTMENT
MORRISVILLE, VERMONT

GREEN RIVER STORAGE PROJEC
GENERAL PLAN

CHAS. T. MAIN, INC. ENGINEERS





HOLE NO.	NORTH	EAST	DEPTH
1	1130	16	16
2	1133	20	20
3	1132	22	22
4	1131	24	24
5	1130	24	24
6	1129	24	24
7	1128	24	24
8	1127	24	24
9	1126	24	24
10	1125	24	24
11	1124	24	24
12	1123	24	24
13	1122	24	24
14	1121	24	24
15	1120	24	24
16	1119	24	24
17	1136	24	24
18	1135	24	24
19	1134	24	24
20	1133	24	24
21	1133	24	24
22	1134	24	24
23	1135	24	24
24	1135	24	24
25	1135	24	24
26	1137	24	24
27	1138	24	24
28	1137	24	24
29	1138	24	24
30	1138	24	24
30A	1138	24	24
31	1137	24	24
32	1137	24	24
33	1136	24	24
34	1136	24	24
35	1135	24	24

REVISIONS	
4-2-46	Coord. notes changed
2-9-46	Revised as built

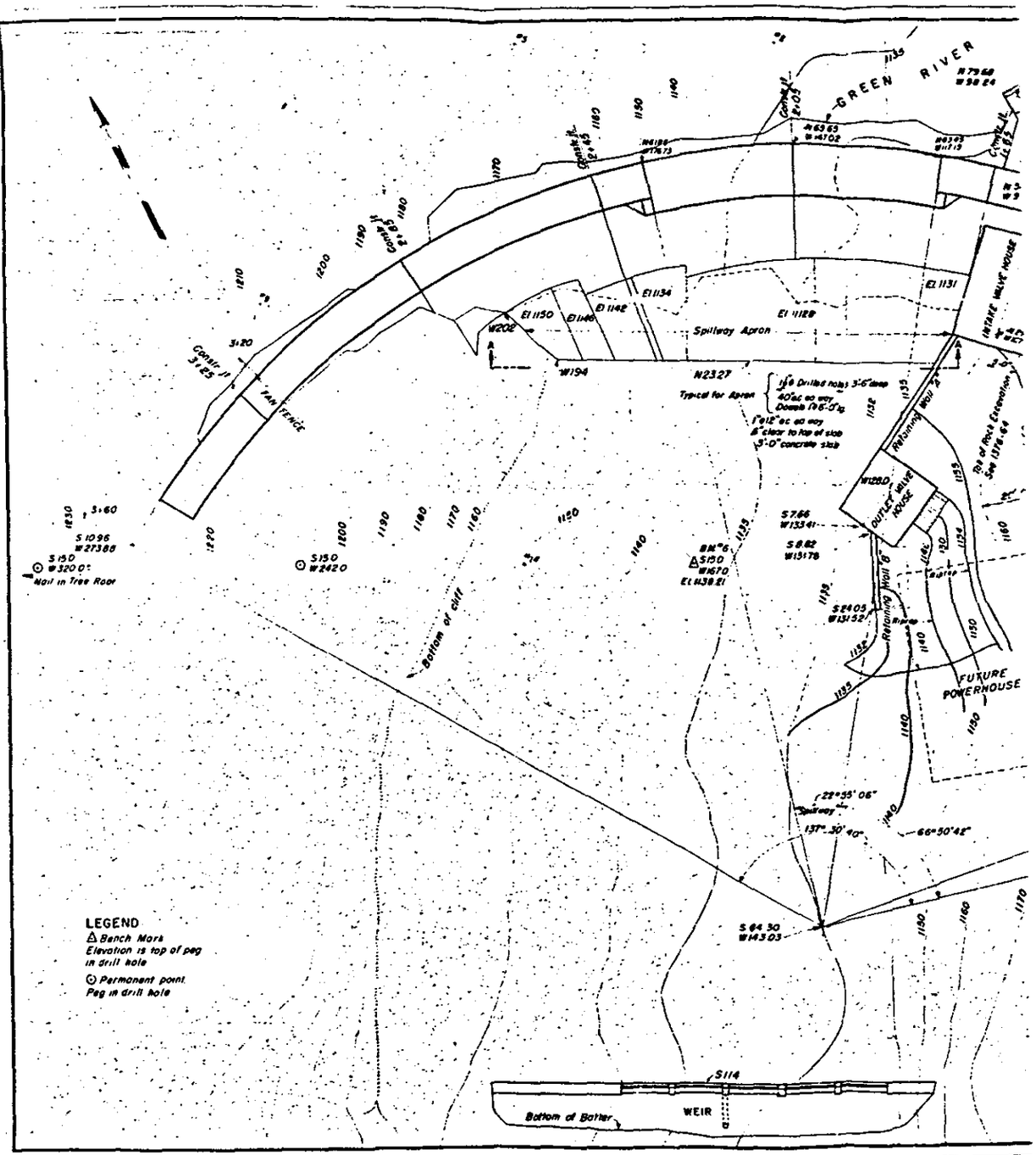
VILLAGE OF MORRISV
WATER AND LIGHT DEPA
MORRISVILLE, VERMO
GREEN RIVER STORAGE D
DAM-FOUNDATION GROUTIN

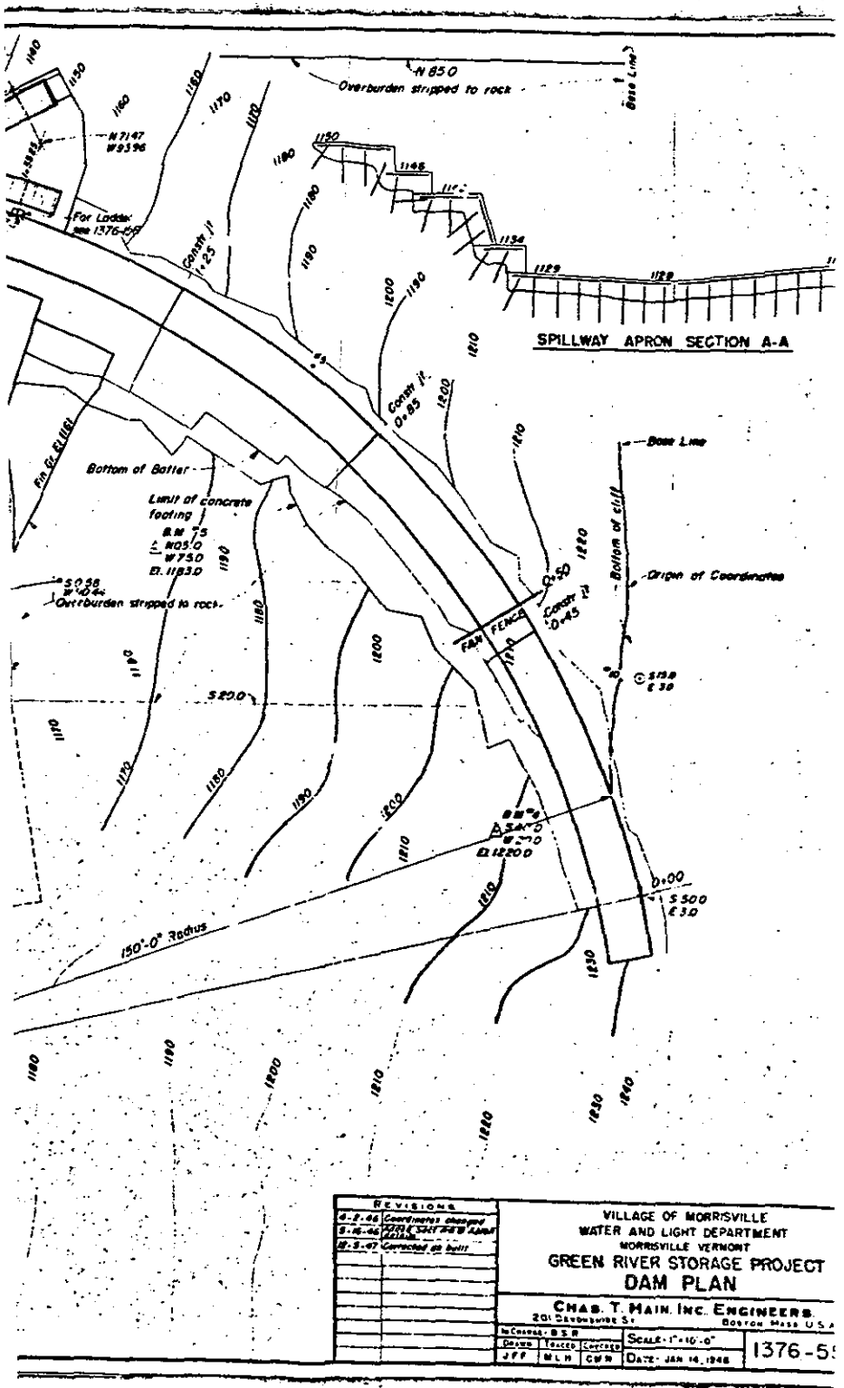
CHAS. T. MAIN, INC.
201 DEVONSHIRE ST. BOSTON, M

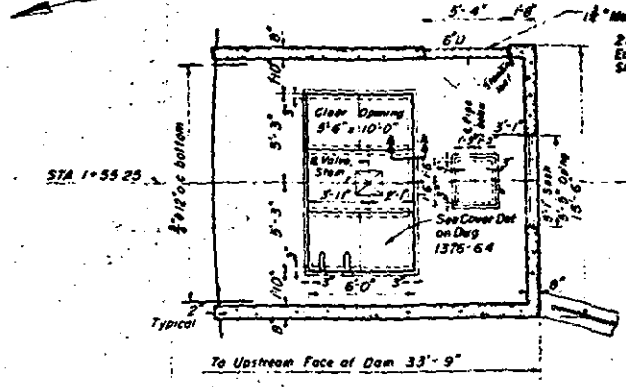
DESIGNED BY	TRACED BY	CHECKED BY
J.F.F.		C.W.M.

SCALE: 1in = 10ft
DATE: OCT. 17, 1945

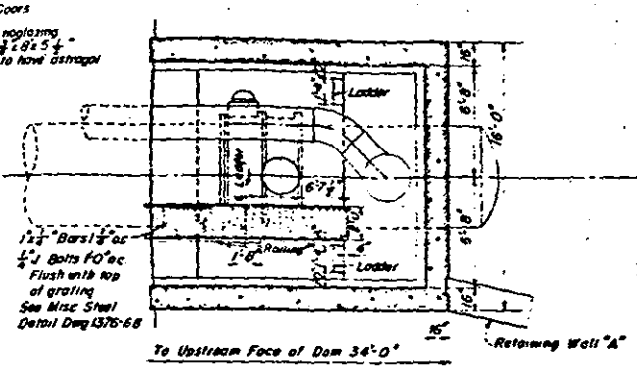
137


GREEN RIVER
Spillway Apron
INTAKE VALVE HOUSE
OUTLET VALVE HOUSE
Retaining Wall
FUTURE POWERHOUSE
Bottom of cliff
FAN FENCE
WEIR
Bottom of Batter
Top of Rock Excavation
See 1376-64
Drilled holes 3'-6" deep
Dowels (#6) 3'-0" lg
3'-0" concrete slab
Nail in Tree Root
BM "6"
El 1138.21
Spillway
LEGEND
Bench Mark
Elevation is top of peg in drill hole
Permanent point
Peg in drill hole

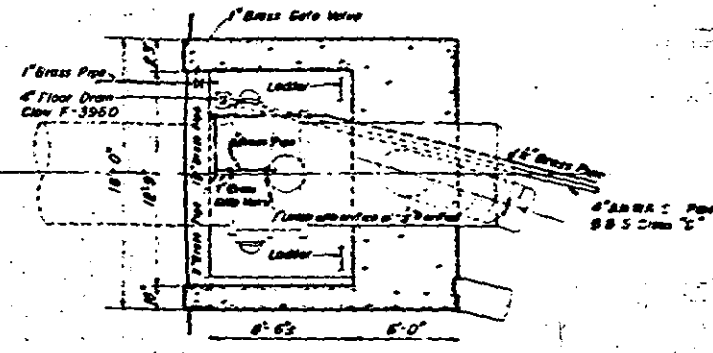

SPILLWAY APRON SECTION A-A
Overburden stripped to rock
For Ladder see 1376-69
Bottom of Batter
Limit of concrete footing
Base Line
Bottom of cliff
Origin of Coordinates
FAN FENCE
150'-0" Radius
REVISIONS
6-2-46 Coordinates changed
5-15-46 Added
10-3-47 Corrected as built
VILLAGE OF MORRISVILLE
WATER AND LIGHT DEPARTMENT
MORRISVILLE VERMONT
GREEN RIVER STORAGE PROJECT
DAM PLAN
CHAS. T. MAIN, INC. ENGINEERS
BOSTON MASS U.S.A.
SCALE: 1"=10'-0"
DATE: JAN 14, 1946
1376-5



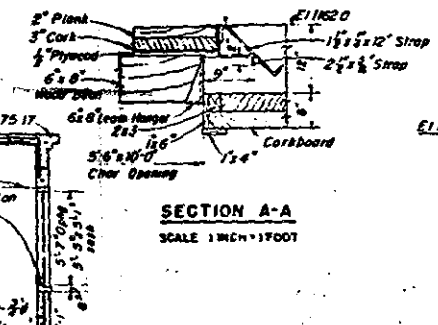
PLAN AT EL. 1162.0



PLAN EL. 1152.5

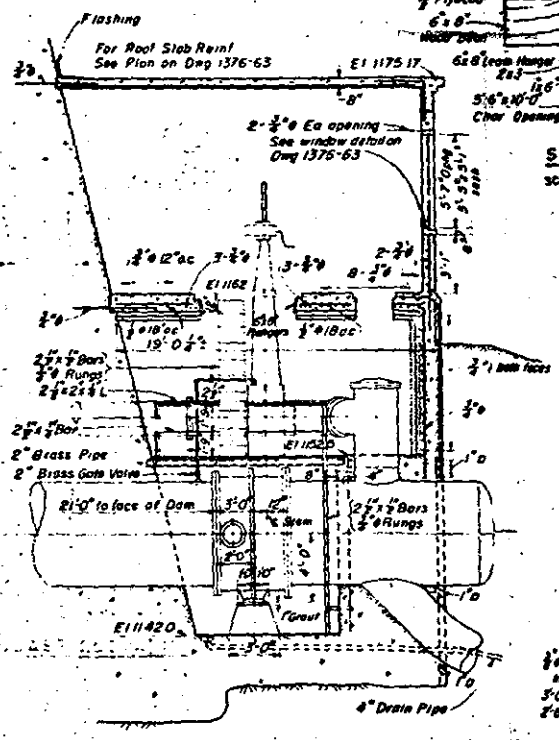


PLAN AT EL. 1151.5



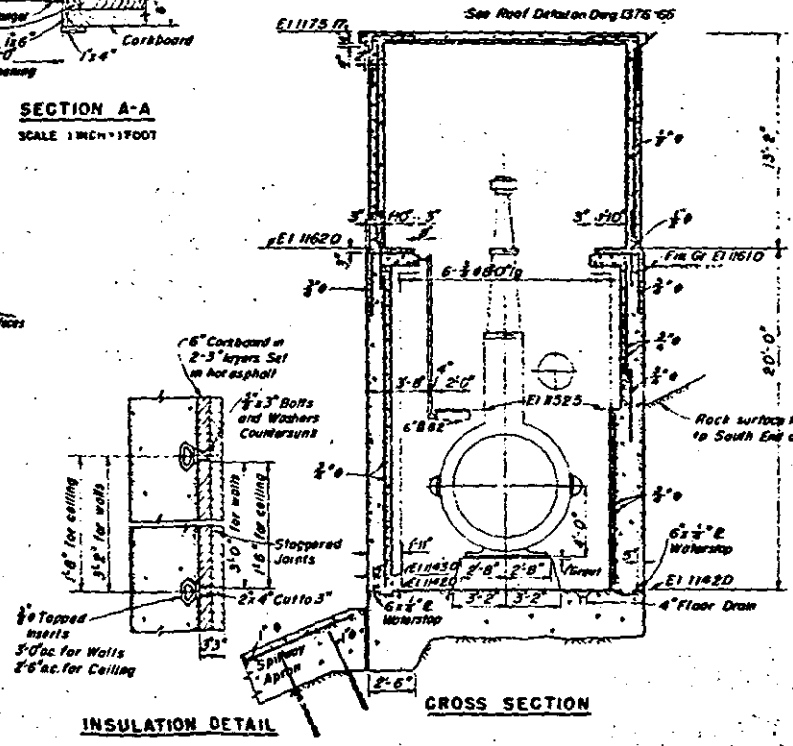
SECTION A-A

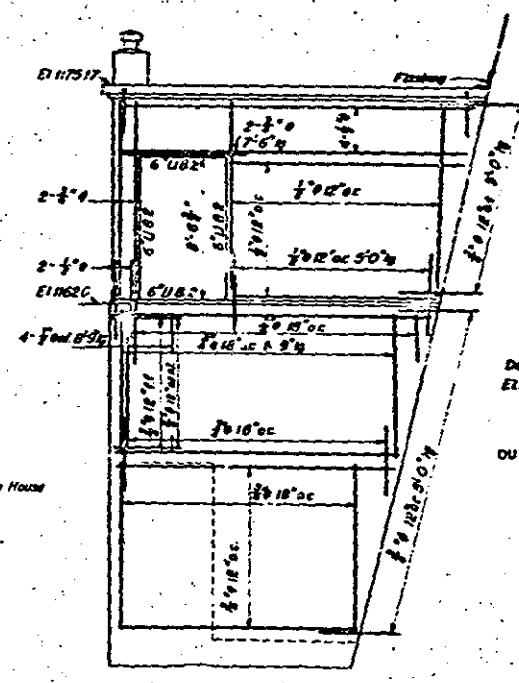
SCALE 1 INCH = 1 FOOT

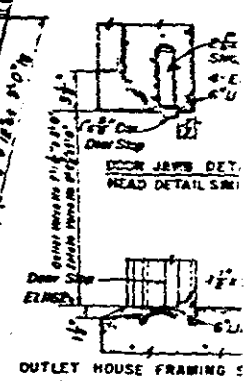


SECTION ALONG STA. 1+55.25

SCALE: ½ INCH = 1 FOOT







OUTLET HOUSE FRAMING S

THRESHOLD DETA

SCALE: 1½ INCHES = 1 FOOT

FOR WEST ELEVATI SEE DWG 1376-63

FOR SOUTH ELEVATIO SEE DWG 1376-64

EAST ELEVATION

REVISIONS			
DEC. 1947	REVISED AS BUILT		

VILLAGE OF MORRISVILLE
WATER AND LIGHT DEPARTMEN
MORRISVILLE, VERMONT

GREEN RIVER STORAGE PR
INTAKE VALVE HOUS

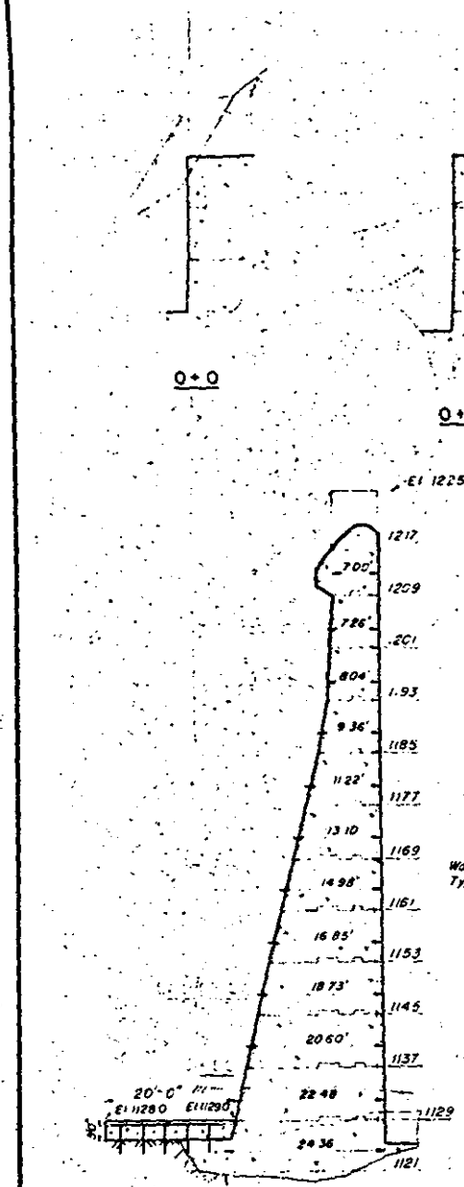
CHAS. T. MAIN, INC. ENGINEER
201 DEVONSHIRE ST. BOSTON, MASS

DESIGNED	DRAWN	TRACED	CHECKED
	JFF	RF	C.W.H.

SCALE: ½" = 1'-0"

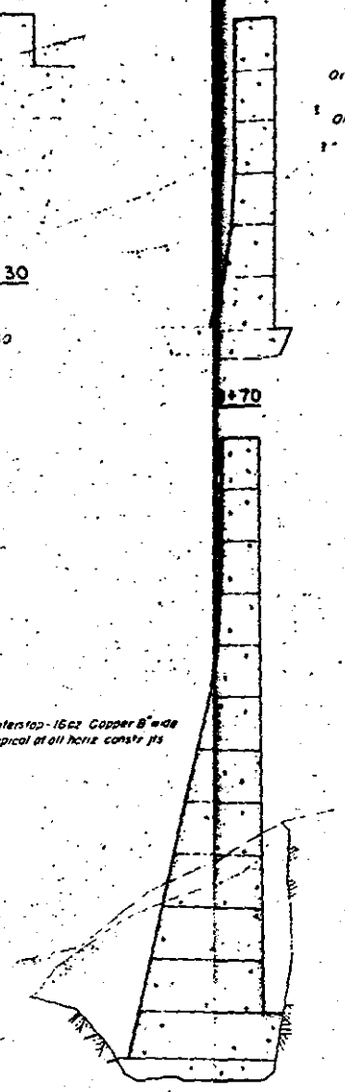
DATE: JAN. 3, 1948

137



DAM STATION 2+05

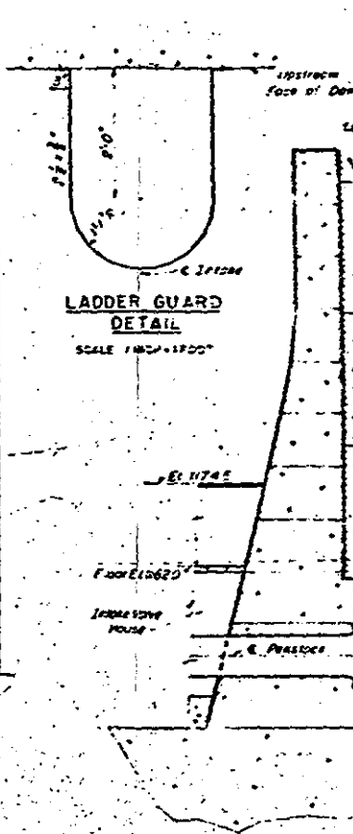
SCALE 1 INCH = 10 FEET

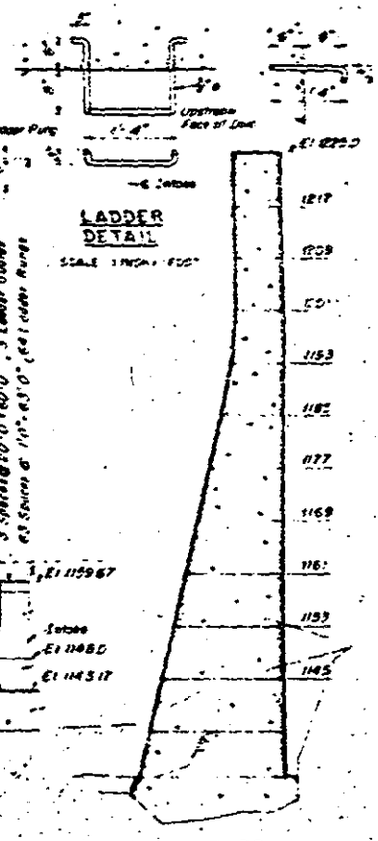


2+48

0+94

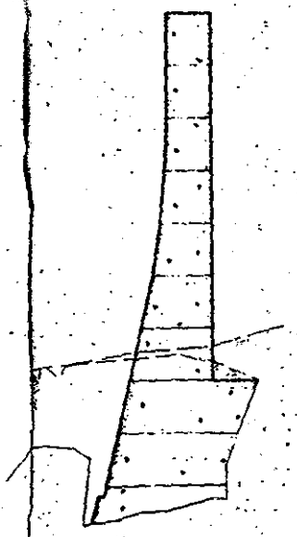
1+20



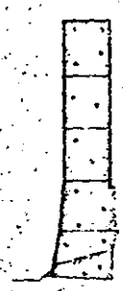


1+55

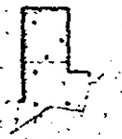
2+30



2+69



2+95



3+20

END OF DAM

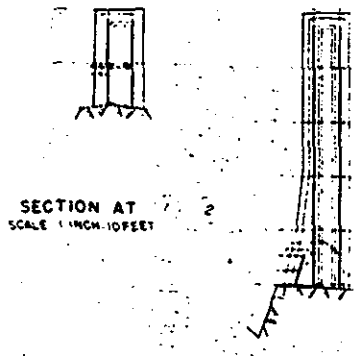
3+50

REVISIONS
12-16-47 REVISED AS BUILT

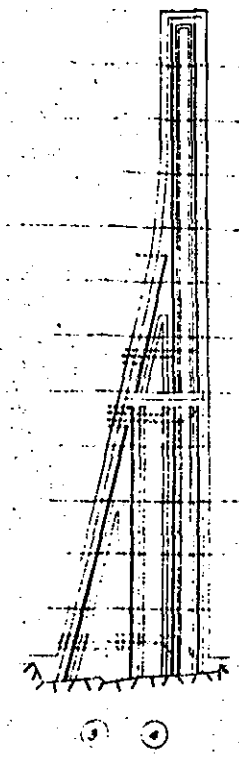
VILLAGE OF MORRISVILLE
WATER AND LIGHT DEPARTMENT
MORRISVILLE, VERMONT
GREEN RIVER STORAGE PROJECT
DAM-SECTIONS

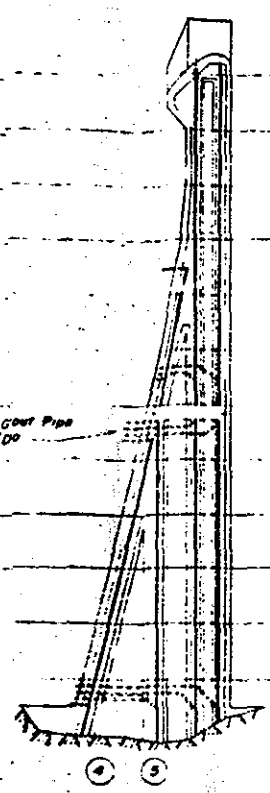
CHAS. T. MAIN, INC. ENGINEERS
201 Devonshire St. Boston Mass. U.S.A.

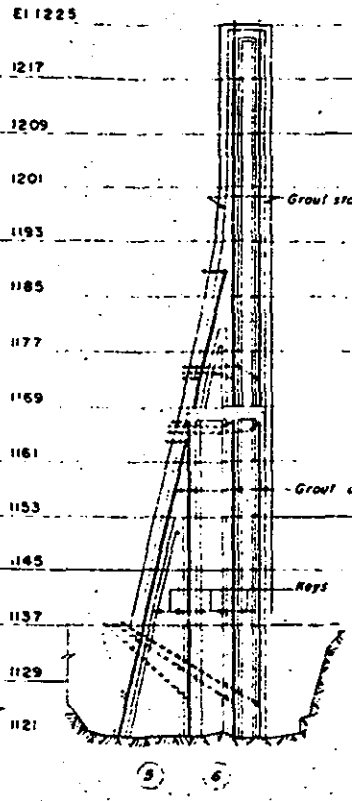
In Charge: B.B. ROSE	Scale: 1" = 10'-0"	1376-5(
Drawn: JFP	Traced: MF	Checked: CWH
Date: Nov 10, 1945		

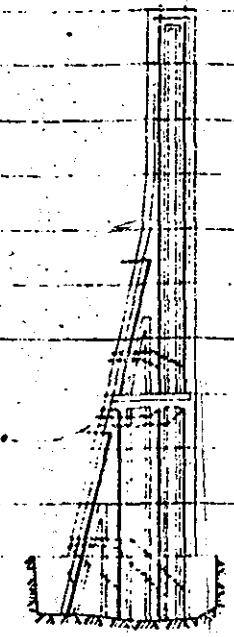


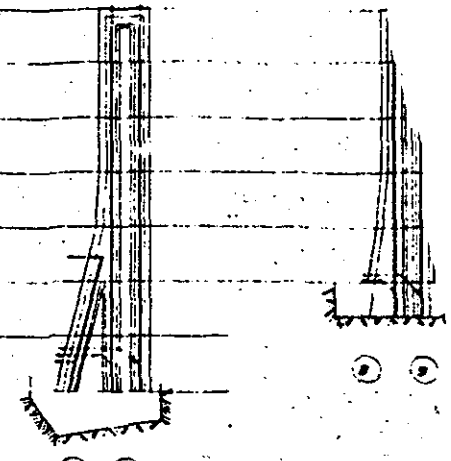
SECTION AT
SCALE 1 INCH-10FEET

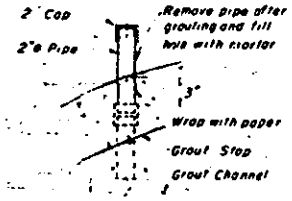




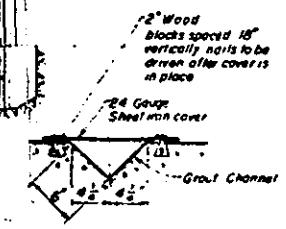




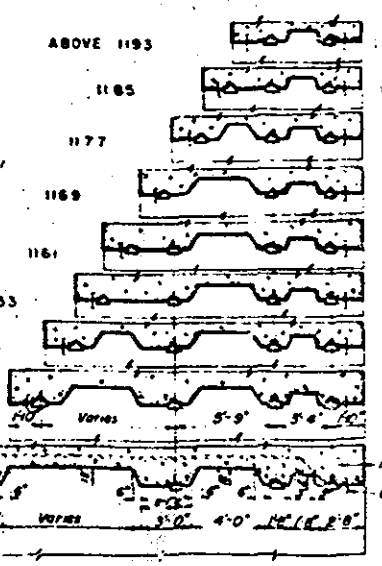




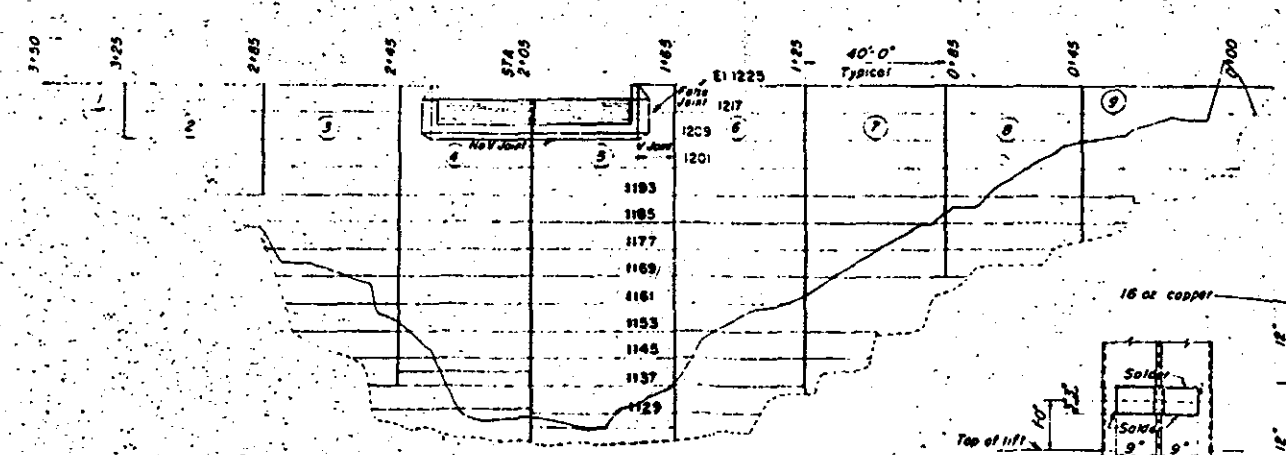
PIPE EXIT DETAIL
SCALE 1½ INCHES-1FOOT



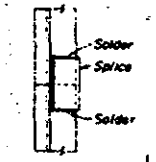
COVER PLATE DETAIL
SCALE 1½ INCHES=1FOOT



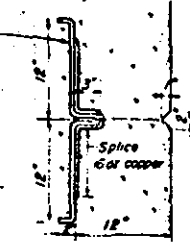
HORIZONTAL SECTIONS
THRU VERTICAL JOINTS
SCALE ½ INCH=1 FOOT



DEVELOPED ELEVATION CONSTRUCTION JOINTS
SCALE: 1 INCH = 20 FEET



GROUT STOP SPLICE
ELEVATION
SCALE: ½ INCH=1FOOT

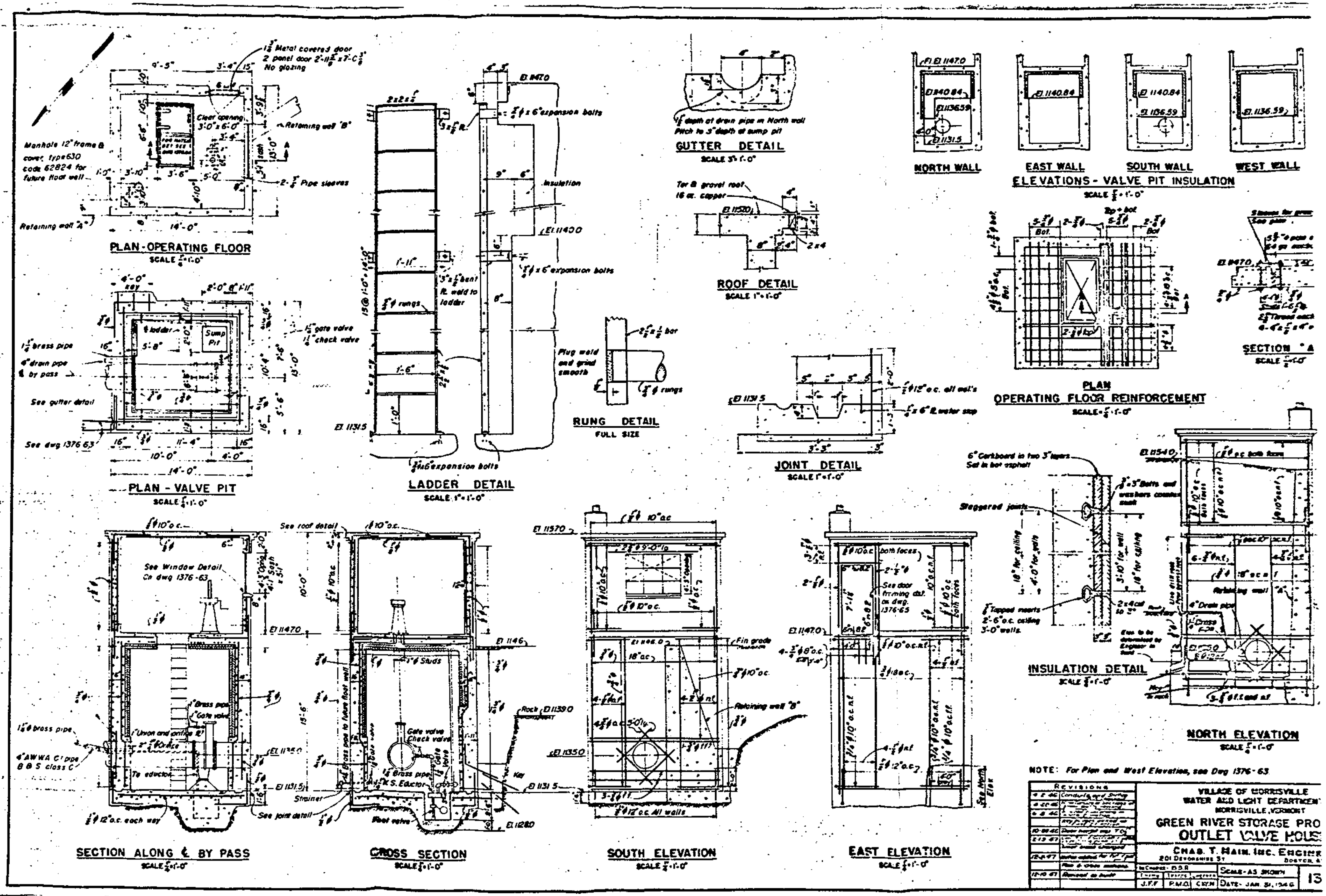


GROUT STOP DETAIL
VERTICAL JOINTS
SCALE 1½ INCHES=1FOOT

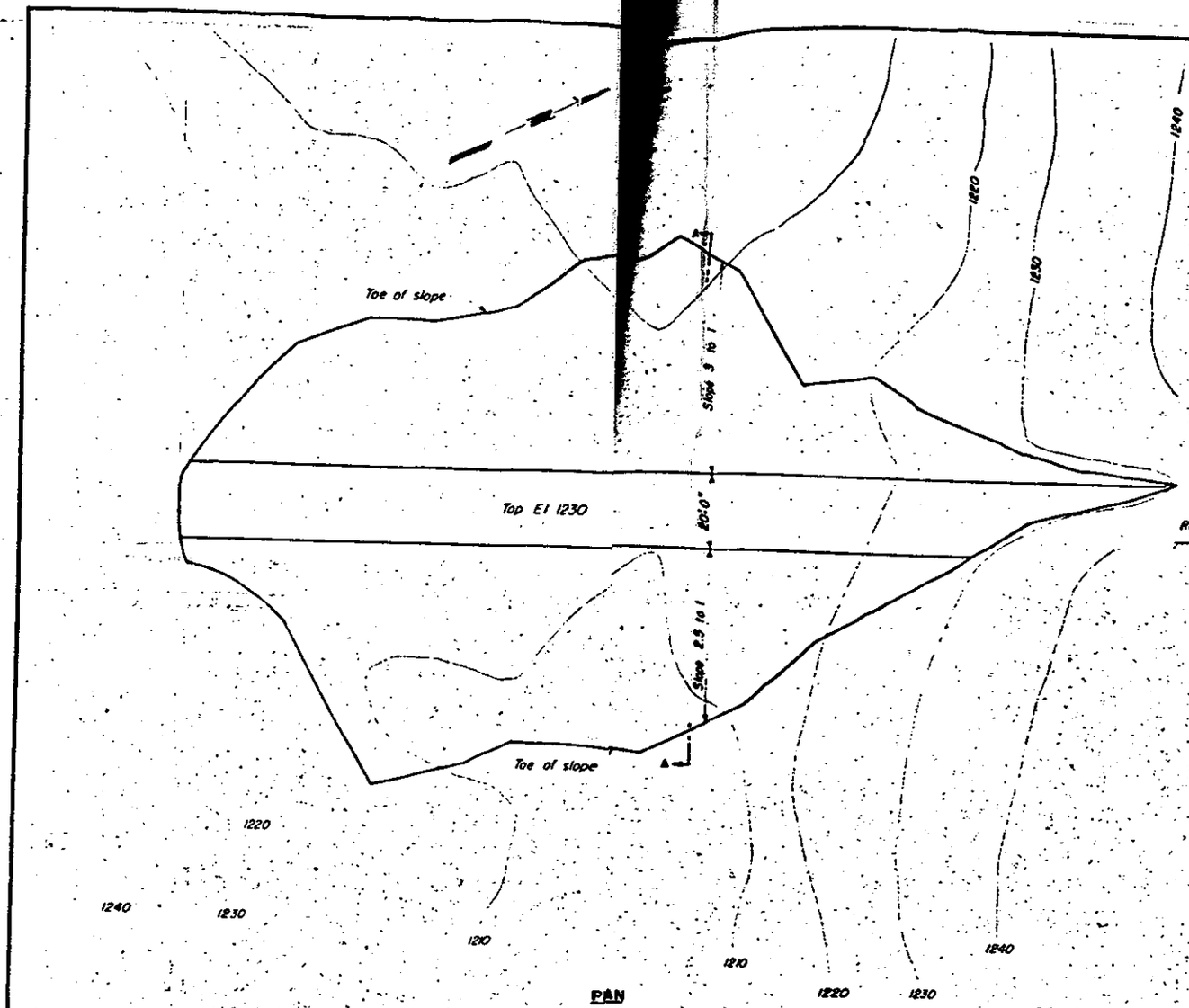
REVISIONS	
DATE	BY
DECEMBER 1945	REVISED AS BUILT

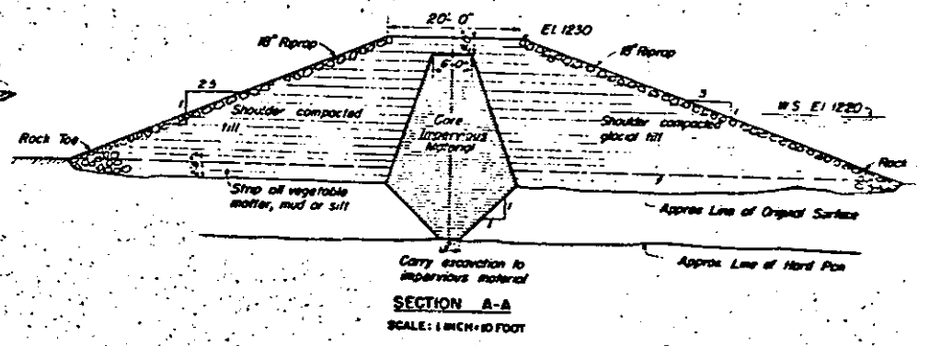
VILLAGE OF MORRISVILLE
WATER AND LIGHT DEPARTMENT
MORRISVILLE, VERMONT
GREEN RIVER STORAGE PROJE
DAM-VERTICAL CONSTRUCTION JO
CHAS. T. MAIN, INC ENGINEERS
201 Devonshire St Boston Mass U

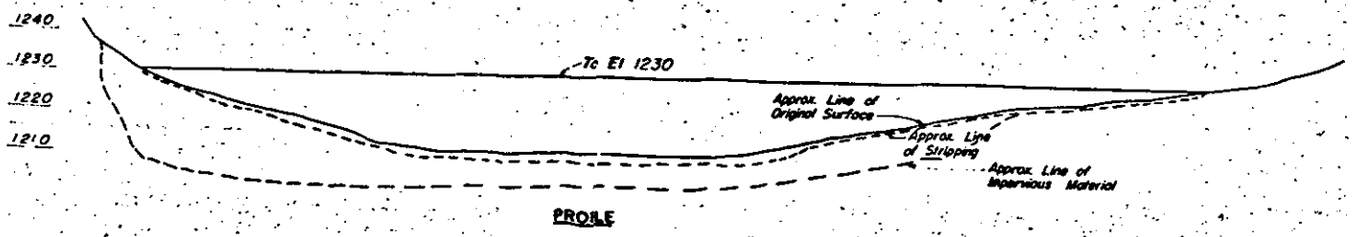
In Charge-RS PHR		Scale-as noted	1376
Traced	Tried	Checked	
JFF	RF	CWR	Date-NOV 15, 1945



PLAN - OPERATING FLOOR
SCALE 1/4"=1'-0"
PLAN - VALVE PIT
SCALE 1/4"=1'-0"
LADDER DETAIL
SCALE 1"=1'-0"
RUNG DETAIL
FULL SIZE
GUTTER DETAIL
ROOF DETAIL
SCALE 1"=1'-0"
JOINT DETAIL
SCALE 1"=1'-0"
NORTH WALL
EAST WALL
SOUTH WALL
WEST WALL
ELEVATIONS - VALVE PIT INSULATION
PLAN
OPERATING FLOOR REINFORCEMENT
SECTION "A
INSULATION DETAIL
NORTH ELEVATION
SECTION ALONG ℄ BY PASS
CROSS SECTION
SOUTH ELEVATION
EAST ELEVATION
NOTE: For Plan and West Elevation, see Dwg 1376-63
REVISIONS
VILLAGE OF MORRISVILLE
WATER AND LIGHT DEPARTMENT
MORRISVILLE, VERMONT
GREEN RIVER STORAGE PRO
OUTLET VALVE HOUS
CHAS. T. MAIN, INC. ENGINE
201 DEVONSHIRE ST
SCALE - AS SHOWN
DATE - JAN. 31, 1946







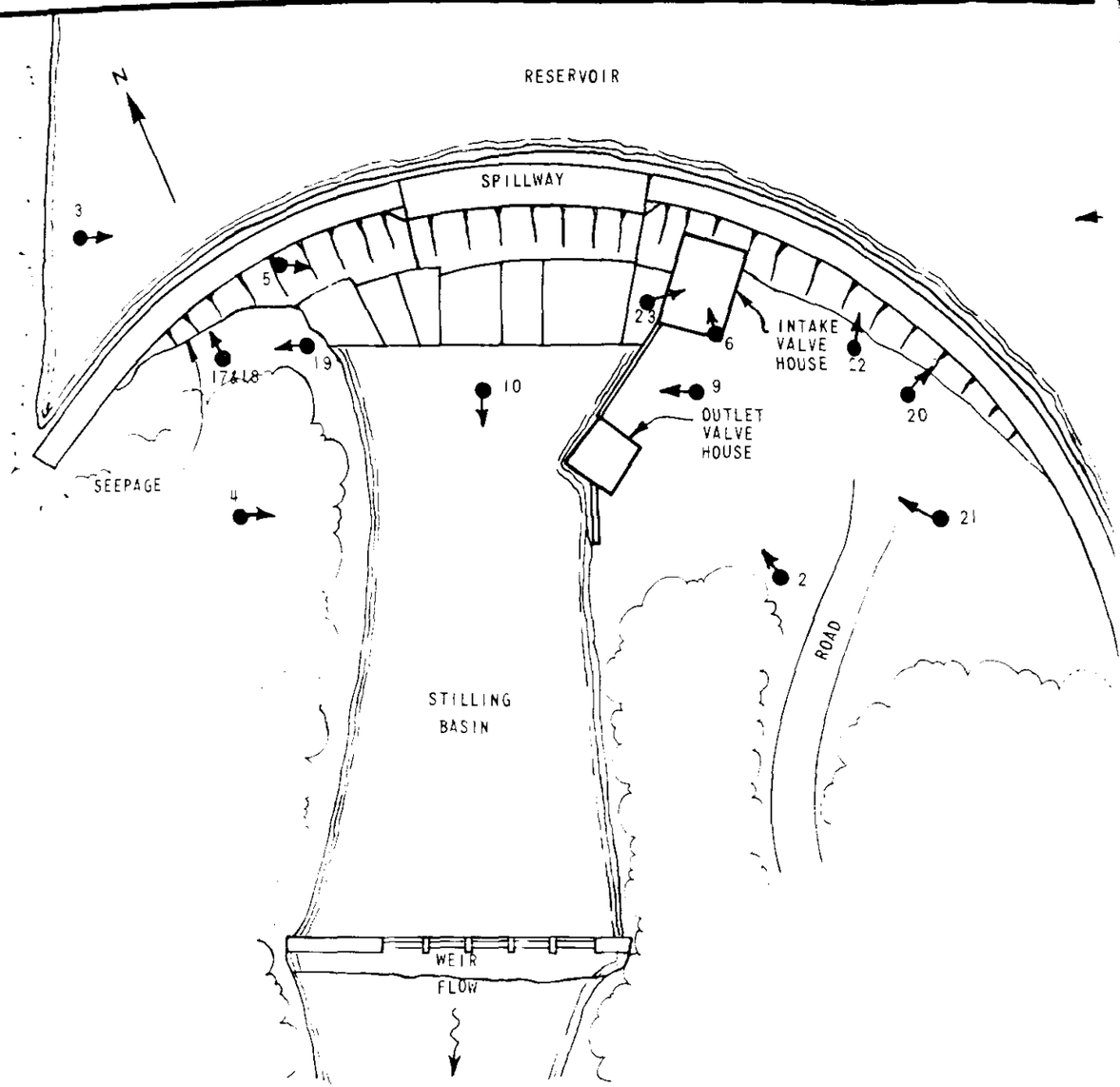
REVISIONS	
12-17-47	Revised as built

VILLAGE OF MORRISVILLE
MORRISVILLE, VERMONT
WATER AND LIGHT DEPARTMENT
GREEN RIVER STORAGE PROJECT
DIKE - GENERAL PLAN

CHAS. T. MAIN, INC. ENGINEERS
201 DEVONSHIRE ST. BOSTON MASS. U.S.A.

In Charge: BSR			Scale: 1" = 10'
Drawn: MD	Traced: PMD	Checked: CMM	Date: OCT. 2, 1945

1376-71

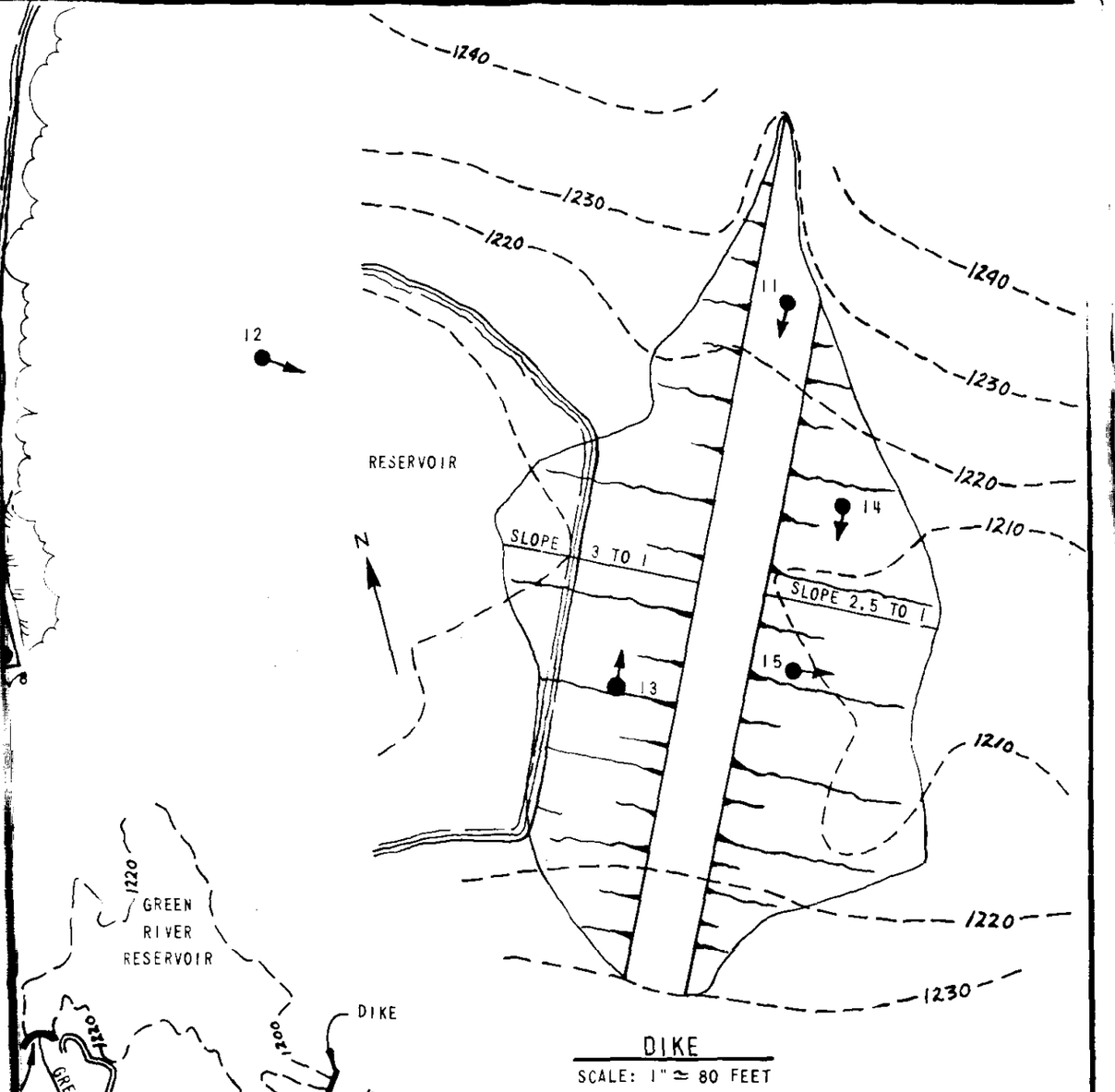


CONCRETE ARCH DAM

SCALE: 1" ≃ 30 FEET

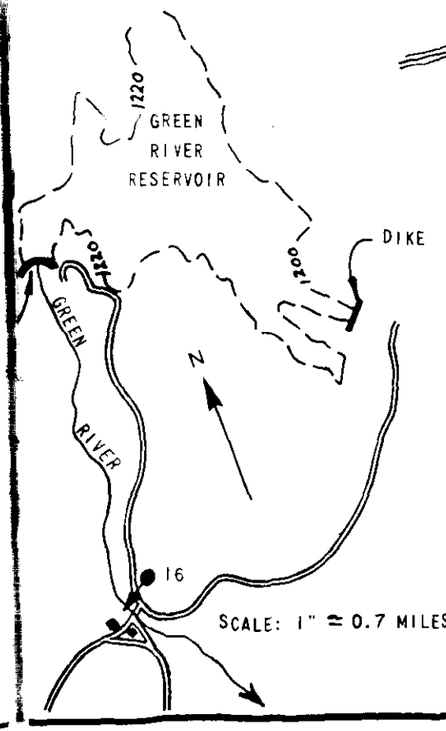
ARCH DAM

3 PHOTO INDEX AND DIRECTION



DIKE

SCALE: 1" ≃ 80 FEET



SCALE: 1" ≃ 0.7 MILES

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NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

PHOTOGRAPH LOCATION PLAN

GREEN RIVER RESERVOIR

CLIENT NO.	04-0094		SCALE AS NOTED
ENG.	SGF		DATE

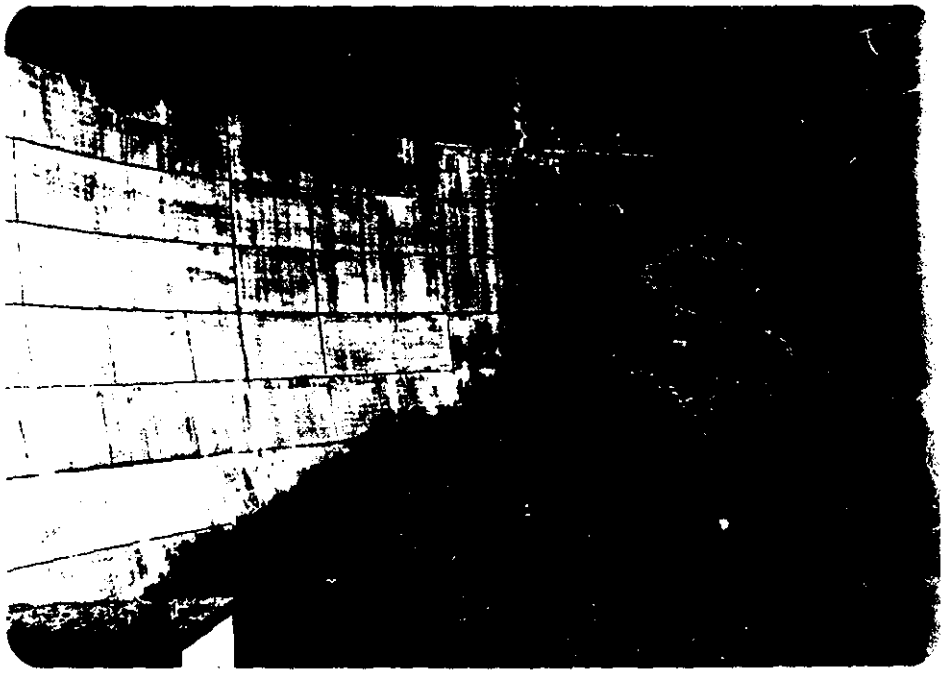
APPENDIX C

PHOTOGRAPHS

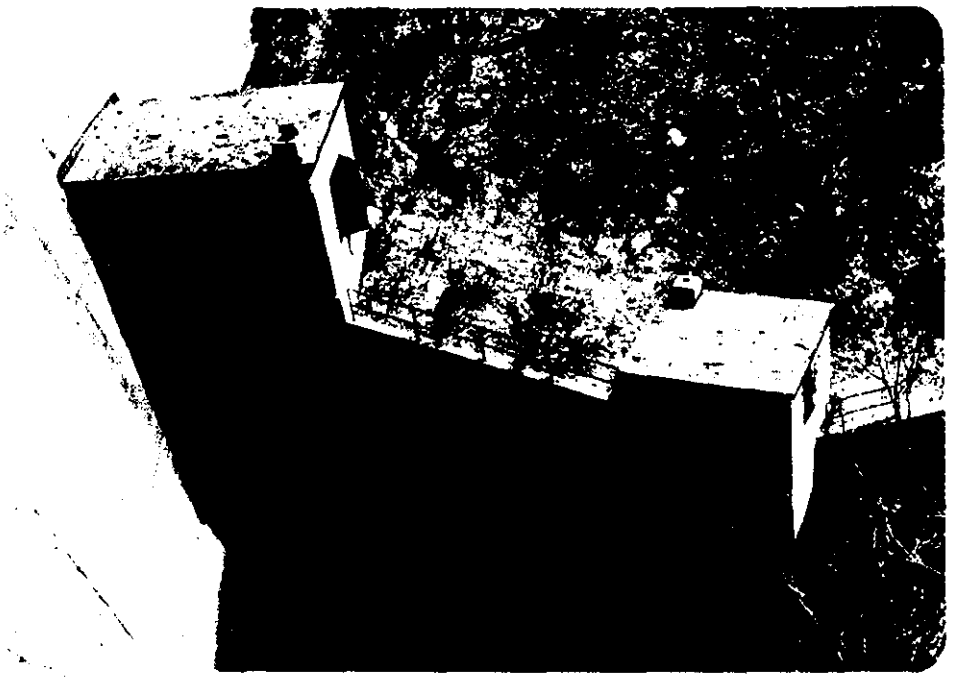
1. GREEN RIVER RESERVOIR DAM

2. DOWNSTREAM VIEW OF DAM, VALVE HOUSE, SPILLWAY

3. CONSTRUCTION PHOTOGRAPH, LEFT ABUTMENT CONTACT



4. LEFT ABUTMENT CONTACT



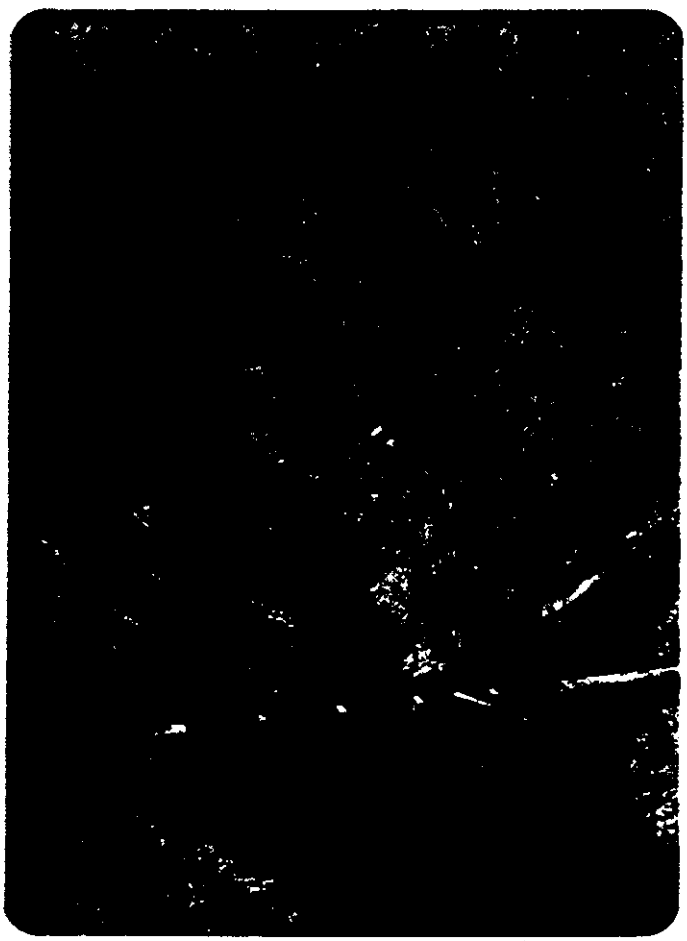
5. VALVE HOUSES, PENSTOCK VALVE, AND BYPASS VALVE

6. OPERATOR FOR PENSTOCK VALVE

7. DAM CREST FROM LEFT ABUTMENT

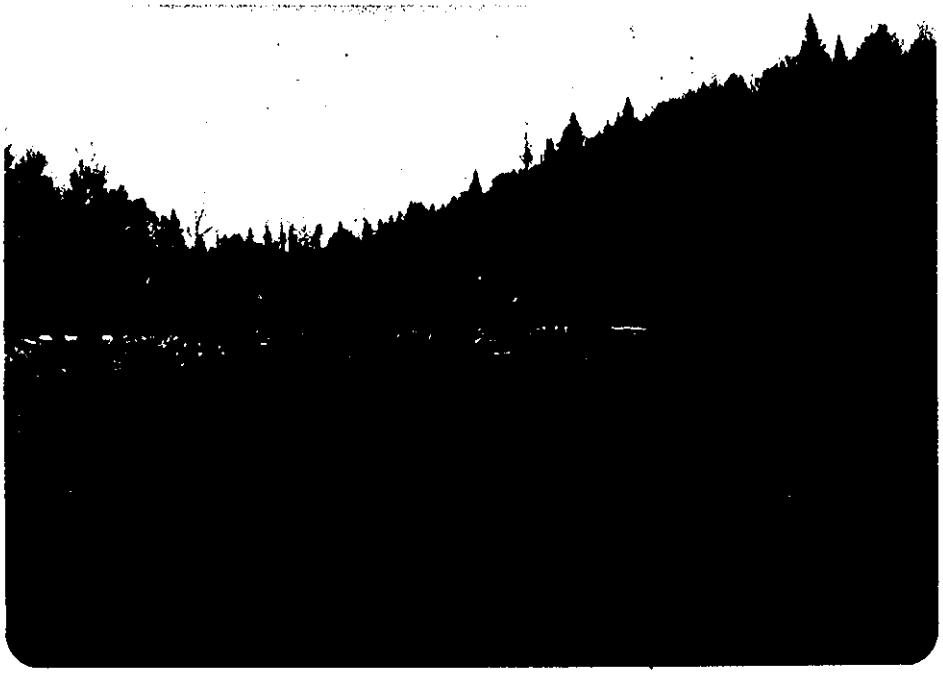
8. SURFACE DETERIORATION OF CONCRETE ON FIRST SECTION OF CREST, LEFT SIDE

9. RIGHT ABUTMENT CONTACT



10. STILLING POOL & DAM BELOW SPILLWAY

11. CREST OF DIKE, LOOKING SOUTHWEST



12. UPSTREAM FACE OF DIKE

13. UPSTREAM FACE OF DIKE

14. DOWNSTREAM FACE OF DIKE

15. DOWNSTREAM CHANNEL BELOW GREEN RIVER RESERVOIR DIKE

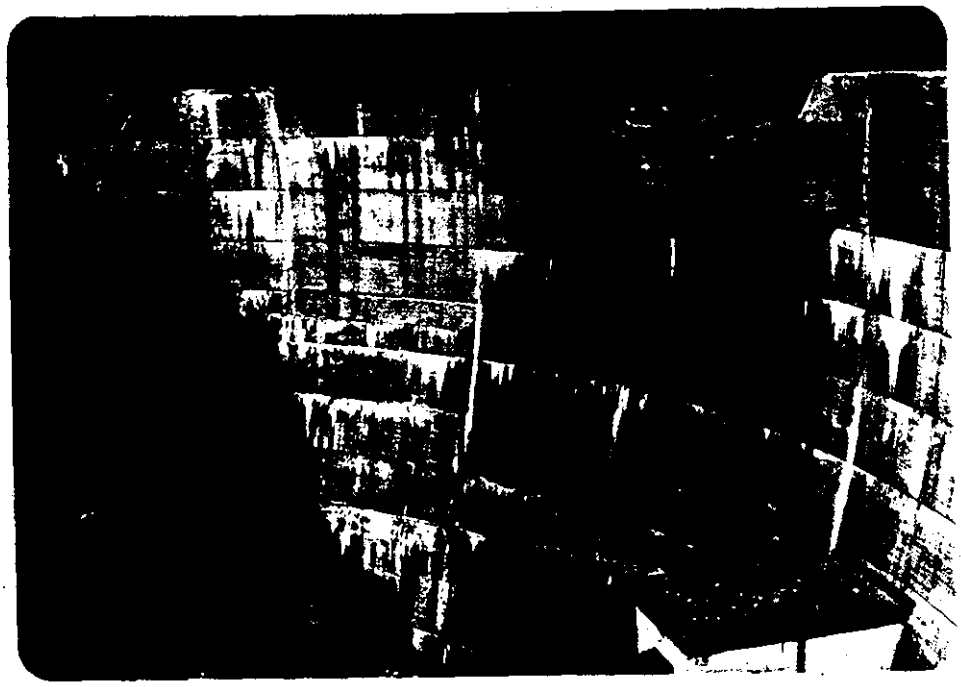
16. FIRST HOMES DOWNSTREAM 1.5 MILES OF GREEN RIVER RESERVOIR DAM

17. RIGHT ABUTMENT CONTACT TO LEDGE

18. SEEPAGE UNDER RIGHT ABUTMENT 40 FEET DOWN FROM DAM CREST

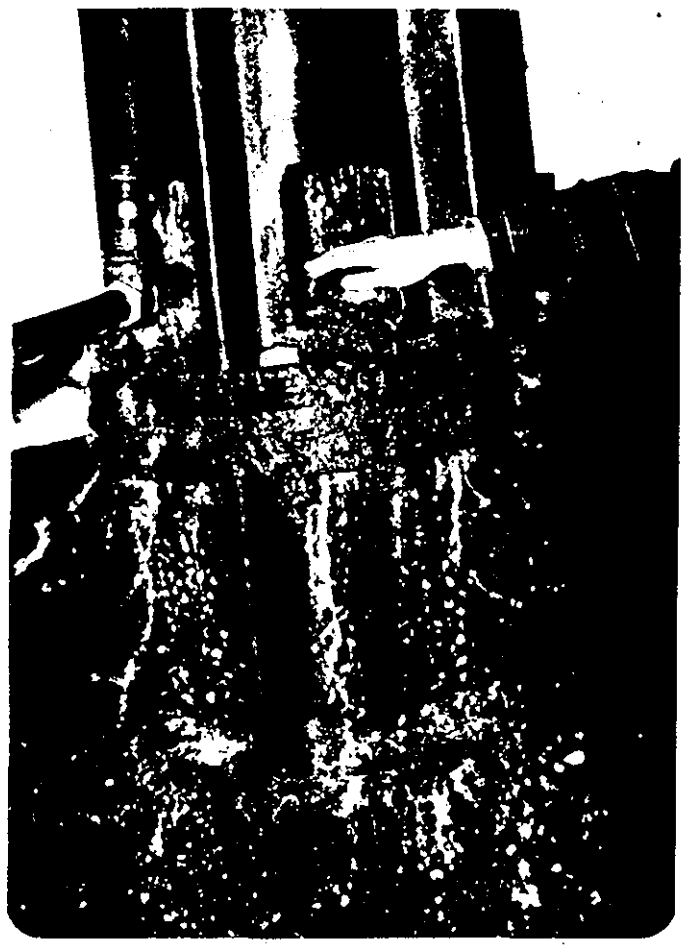
19. SEEPAGE AT RIGHT ABUTMENT, 20 FEET DOWNSTREAM OF THE DAM

20. RAT HOLE IN CRETE
NEAR LEFT AB ENT
(SEE PHOTO # AT
CENTER OF P 0)



21. RIGHT ABUTMENT SHOWING INTERFACE BETWEEN CONCRETE AND ROCK

22. CLOSE-UP OF EFFLORESCENCE AT CONSTRUCTION JOINTS



23. LEAKAGE FROM PENSTOCK VALVE PACKING ID

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

CONTENTS

DUFRESNE-HENRY ENGINEERING CORPORATION

SHERWARD G. FARNSWORTH
8-10-79

SUBJECT GREEN RIVER RESERVOIR
DAM, DIKE & RESERVOIR INFORMATION

SHEET NO. 1 OF ___
JOB NO. 04-0094

DAM, CONCRETE ARCH

LENGTH 360 ± FEET, EFFECTIVE HYDRAULIC LENGTH DUE TO LEDGE AT LEFT ABOUTMENT (25') = 325 FT

HEIGHT 97 FEET

WIDTH @ TOP 7 FEET
@ BASE 23.6 FEET (MAX.)

SPILLWAY 60 FOOT BY 5 FOOT OGEE WEIR

ELEVATIONS

BASE OF DAM :	1128	FEET ABOVE M.S.L.
SPILLWAY :	1220	" " "
TOP OF DAM :	1225	" " "
PENSTOCK INVERT :	1145	" " "

PENSTOCK

MAIN GATE : 72"
DISCHARGE GATE: 30"

DOWN STEAM STILLING POOL WEIR

LENGTH 79 FEET

HEIGHT 18 FEET

ELEVATIONS

BASE :	1130	FEET ABOVE MEAN SEA LEVEL
SPILLWAY :	1139	" " " " "
TOP :	1147.8	" " " " "

DIKE, EARTH EMBANKMENT

LENGTH 249 FT

HEIGHT 22.0 FT

ELEVATIONS

TOP OF DIKE :	1230	FEET ABOVE MEAN SEA LEVEL
BASE OF DIKE :	1208	" " " " "

STORAGE (AC-FEET)

TOP OF DAM	20,363 ±
INVERT OF SPILLWAY	17,516 ±
35 FEET BELOW SPILLWAY*	5,970 ±
USABLE STORAGE	11,550 ±
TOP OF DIKE	23,990 ±

* MAXIMUM THAT MORRISVILLE ELECTRIC DRAWS RESERVOIR DOWN.

DRAINAGE & POND AREAS

DRAINAGE AREA: $14.23\,IN^2$ ** $\times (5208\ FT/IN.)^2 \times (1\ ACRE/43{,}560\ FT^2) \times (1\ SQ.MI./640\ ACRES)$

D.A. $= 14.23\,IN^2 \times (0.973\ SQ.MI./IN^2) = 13.84$ SQ. MI.

POND AREA: P.A. $= (1.19 - 0.04\,IN^2$ **$) \times (0.973\ SQ.MI./IN^2) = 1.120\ SQ.MI. = 716\ AC.$

FROM GREEN RIVER HEARINGS P.A. = 625 ACRES
FROM VT. WATER RESOURCES TABLE, POND AGE = 754 ACRES
FROM VT. HIGHWAY COUNTY MAP = 736 ACRES

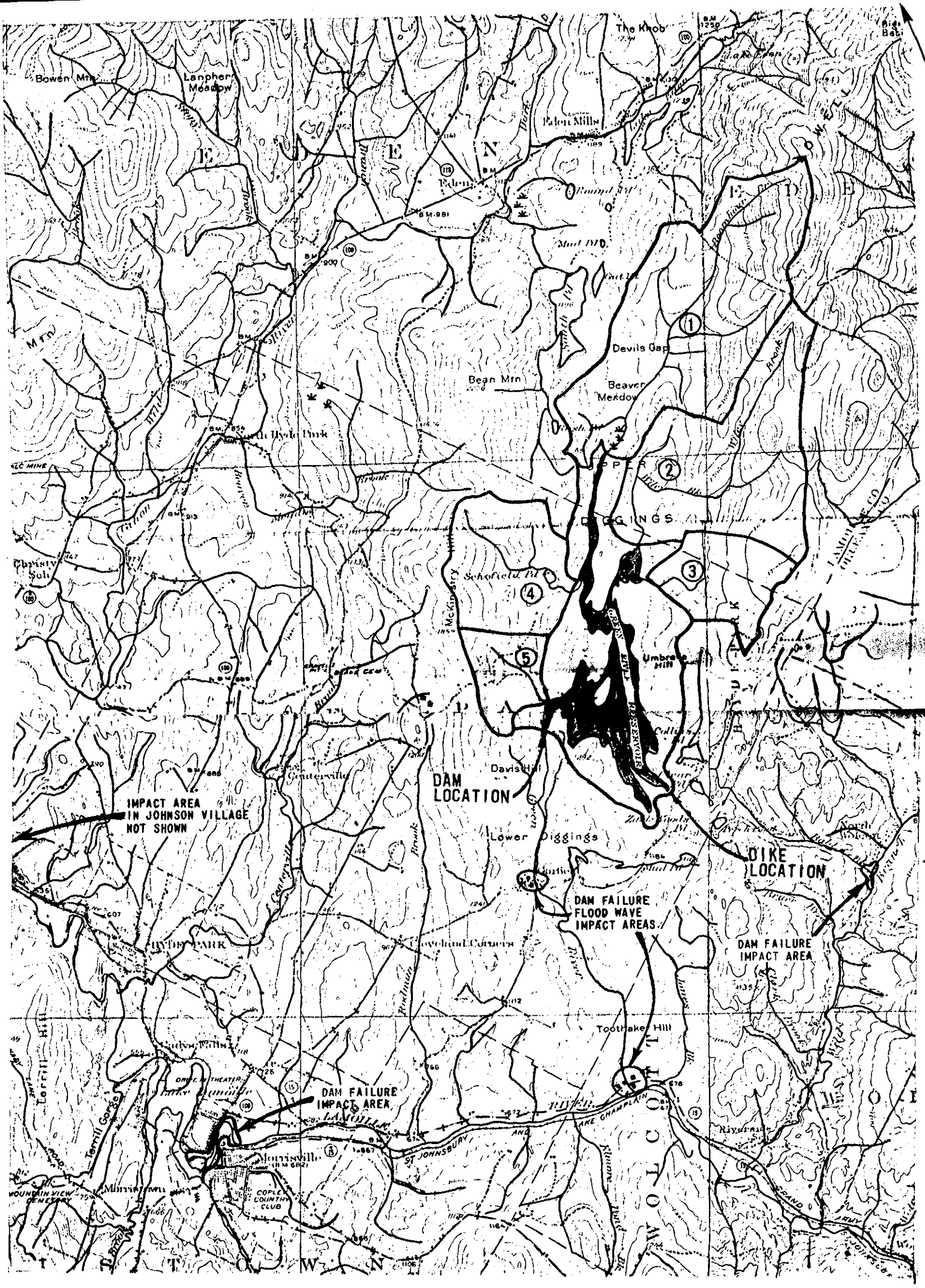
INTERPOLATING FROM GREEN RIVER HEARINGS CAPACITY CURVE:

$$\frac{(837 - 763) \times 10^6\ FT^3}{2.5' \times 43560\ FT^3/AC} = 680\ AC \Rightarrow \text{USING } 6.80\ AC$$

STILLING POOL WEIR

TYPE:	CONCRETE GRAVITY DAM
LENGTH:	79 FEET
HEIGHT:	9 FEET
CREST ELEVATION:	1139.0 FEET ABOVE MEAN SEA LEVEL

** FROM U.S.G.S GEOLOGICAL SURVEY MAPS: HYDE PARK, VT. 1929-1953, 15 MINUTE QUADRANGLE.



SOURCE OF MAP

U.S. GEOLOGICAL SURVEY
HARDWICK, VT. AND
HYDE PARK, VT. QUADRANGLES
15 MIN. SERIES
1:62500 1951 & 1953

(5) DRAINAGE SUB-AREA

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NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

DRAINAGE AREA MAP

GREEN RIVER RESERVOIR

CLIENT NO.	04-0094		SCALE 1:62500
ENGINEER	S.G.F.		DATE 8-10-79

BY S.L. FARNSWORTH
DATE 5-12-79

SUBJECT GREEN RIVER RESERVOIR DAM BREAK COMPUTATIONS WITH FLOOD WAVE

HAZARD CLASSIFICATION COMPUTATIONS

GREEN RIVER RESERVOIR DAM BREAK*

$$Q_{P_1} = \frac{8}{27} W_b \sqrt{g} \, Y_0^{3/2}$$

*WATER AT TOP OF DAM
STORAGE 408×10^6 ft^3 = 20,363 AC-ft (FROM GREEN RIVER PUBLIC BOARD HEARINGS)

$Y_0 = 1225 - 1128 = 97$ ft

W_b = 40% LENGTH OF DAM @ MID HEIGHT = 40%(160') = 64'

$Q_{P_1} = \frac{8}{27}$ (64') $\sqrt{32.2 \text{ ft/sec}^2}$ (97 ft)$^{3/2}$ = 102,800 CFS

COMPUTING FLOOD WAVE HEIGHTS & DISCHARGES @

a. BASE OF STILLING POOL WEIR
b. VILLAGE OF GARFIELD, 8000 ft DOWN STREAM OF DAM.
c. VT HIGHWAY 15, MOUTH OF GREEN RIVER.

A. FLOOD WAVE AT DAM

HEIGHT OF WAVE & AREA?
SEE SHEET #2, CROSS SECTION JUST DOWN STREAM OF DAM.

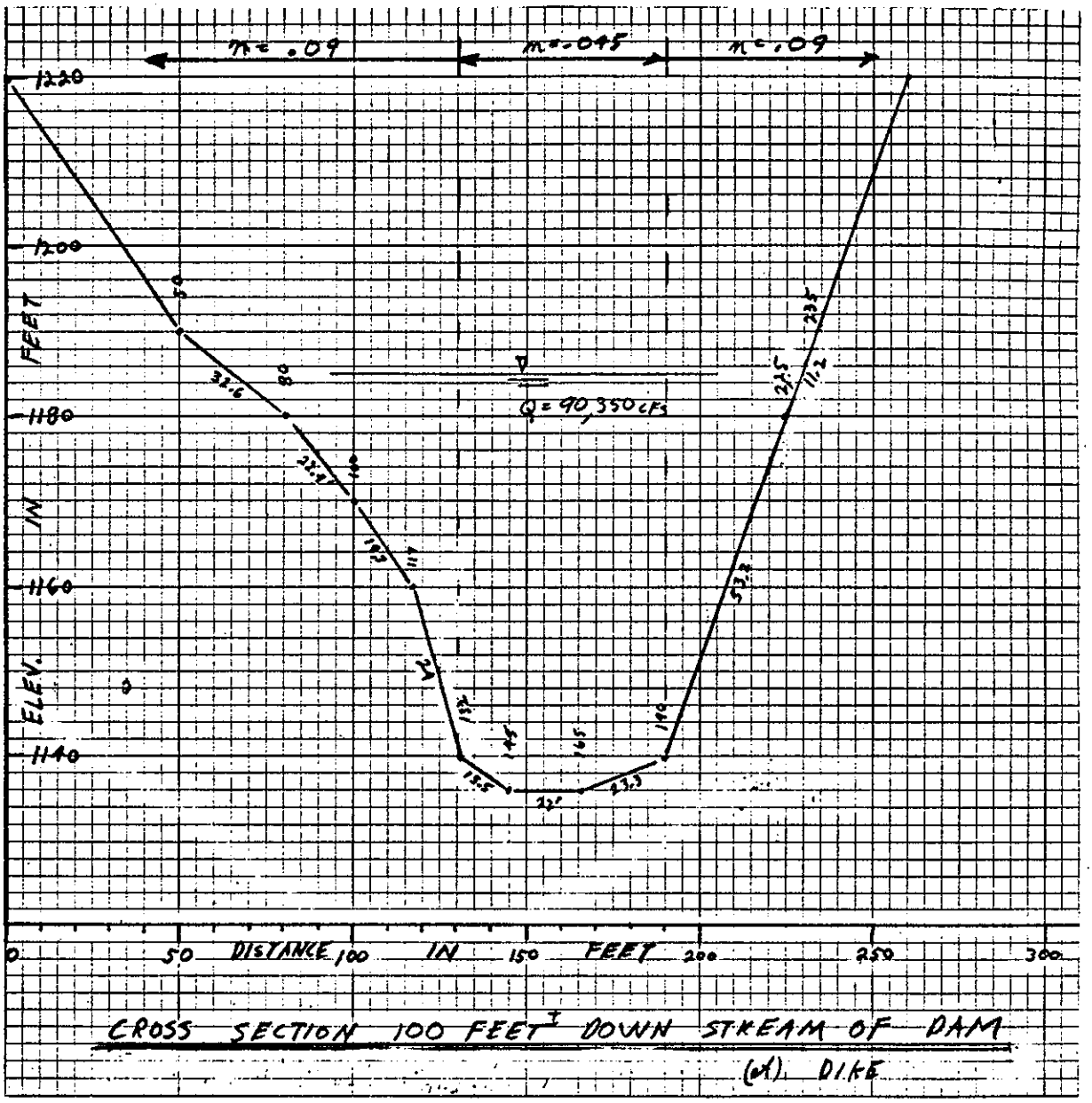
$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2} \qquad R = A/WP$$

$S_0 = .025$ (From sht #2)

ELEVATION (feet)	SUB-AREA COMPUTATIONS				DISCHARGE PER ELEV. (CFS)
	n	AREA (SF)	WP	Q (CFS)	
1180	.09$_L$	805	66.1	11,124	
	.095	1050	60.8	36,629	
	.09$_R$	700 (2550 SF)	53.2	10,185	57,938 CFS
1185	.09$_L$	1103	82.4	16,234	
	.095	1340	60.8	54,998	
	.09$_R$	900 (3343 SF)	58.8	14,485	85,717
1190	.09$_L$	1475	98.7	23363	
	.095	1630	60.8	76235	
	.09$_R$	1100 (4205 SF)	64.4	19046	118,644 CFS

DEPTH OF FLOW @ 102,800 ± CFS = 1187.6 ± feet
∴ AREA = 3791 ± SF

DEPTH OF FLOW ABOVE STREAM BED ≈ 50 ± feet.

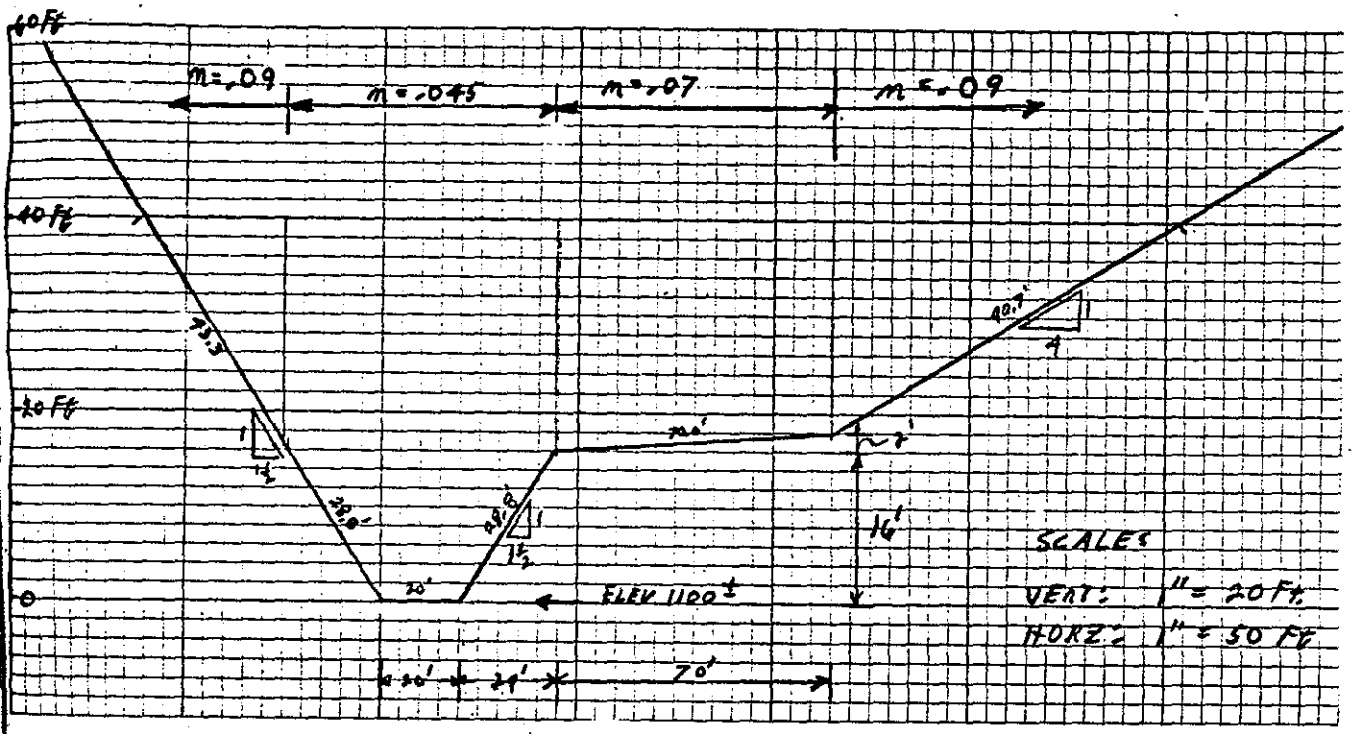


CROSS SECTION 100 FEET DOWN STREAM OF DAM (A). DIKE

REFERARCE: 1974 GREEN RIVER PLANS BY CHARLES T. MAIN, INC. CONTOUR PLAN AT DAM. (SEE APPENDIX B)

FROM U.S.G.S SHEET, X-SECTION SLOPE IS $\frac{20 ft}{800 ft} = 0.025 ft/ft$

B. FLOOD WAVE AT GARFIELD

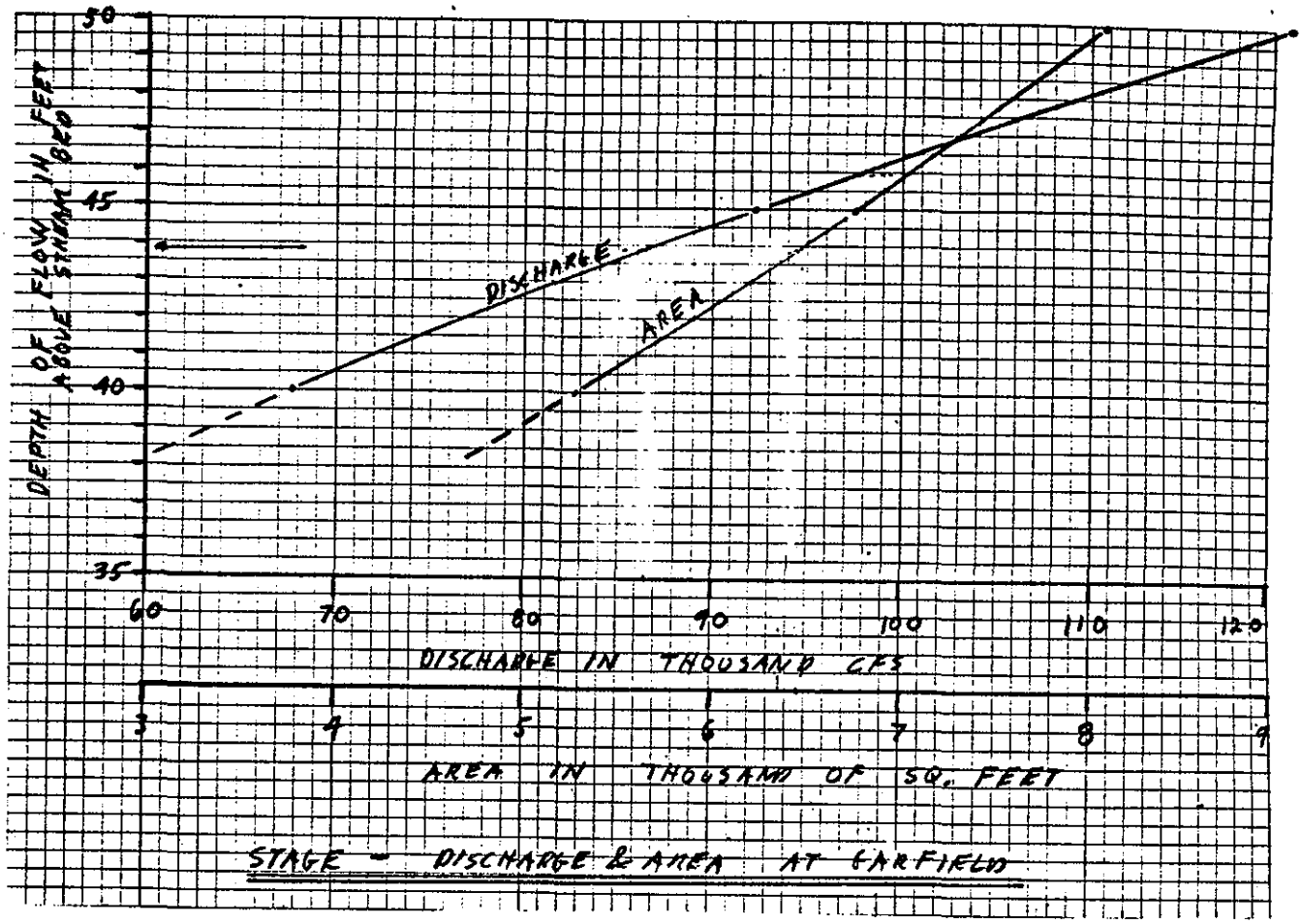


CROSS SECTION JUST UP STREAM OF GARFIELD ROAD OVER GREEN RIVER, 8000 ft DOWN STREAM OF DAM

$S_0 = \frac{20 Ft}{5400 ft} = .0037$ (FROM U.S. G.S. SHEET)

* : $Q = \frac{1.486}{n} A \left(\frac{WP}{A}\right)^{2/3} S_0^{1/2}$

DEPTH OF FLOW (ft)	SUB-AREA COMPUTATIONS				TOTAL DISCHARGE (Q) (CFS)
	n	AREA (SF)	WP	Q * (CFS)	
40	.09L	432	43.2	2,013	
	.045	2336	77.6	45,407	
	.07	1540	70.0	15,613	
	.09R	968	90.7	4,713	67,747 CFS
		5276			
50	.09L	768	61.3	4,161	
	.045	3016	77.6	69,511	
	.07	2440	70.0	33,621	
	.09R	2048	131.9	12,802	120,095 CFS
		8072 SF			
45	.09L	631	52.5	3325	
	.045	2676	77.6	56,947	
	.07	1990	70.0	23,936	
	.09R	1458	111.3	8137	42,345 CFS
		6755			



STAGE - DISCHARGE & AREA AT FARFIELD

FLOOD ROUTING TO FARFIELD:

DISCHARGE @ DAM = 162,800 CFS (FROM SHEET #1)
AREA " " = 3791 SF "
DISTANCE 8000 ft

ASSUMING 95000 CFS DISCHARGE @ FARFIELD

∴ AREA = 63702 SF

∴ VOLUME = [3791 + 6900] ÷ 2 * 8000 ft ÷ 43,560 SF/Ac = 982 Ac-ft

Q_{P_2} (TRIAL) = $Q_{P_1}\left(1 - \frac{V_1}{S}\right)$ = 102,800 CFS $\left(1 - \frac{982 \text{ Ac-ft}}{20,363 \text{ Ac-ft}}\right)$ = 97,843 CFS VS 95000 CFS

ASSUMING 97,500 CFS

AREA FOR 97500 CFS ≈ 7030 SF

VOLUME = (7030 + 3791) ÷ 2 * 8000 ft ÷ 43,560 SF/Ac = 994 Ac-ft

Q_{P_2} = 102,800 CFS $\left(1 - \frac{994 \text{ Ac-ft}}{20,363 \text{ Ac-ft}}\right)$ = 97,781 CFS ≈ 97,500 CFS

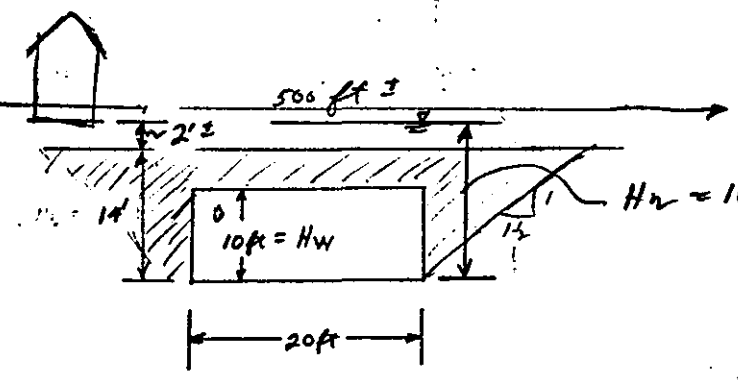
USING Q = 97,800 CFS

∴ DEPTH OF FLOW IS APPROXIMALLY 45 FEET ABOVE THE STREAM BED.

AT THIS LOCATION TWO HOMES AND ONE TRAILER WOULD BE UNDER WATER.

THE LOSS OF LIFE at GARFIELD WOULD BE AROUND 10 PERSONS. AND BECAUSE TO EXISTING CHANNEL AT HIGHWAY, VT 15 IS TOO SMALL TO HANDLE THE FLOOD WAVE, THIS WOULD INCREASE THE LOSE BY ANOTHER 8-12 PERSONS AND THEREFORE. BY RECOMMENDED GUIDELINES CLASSIFY THIS DAM AS A HIGH HAZARD CLASSIFICATION DAM.

VT 15 HIGHWAY BRIDGE
REIN. CONCRETE BOX
10 FOOT BY 20 FOOT
WITH 45° WING WALL FLARE



MAXIMUM FLOOD WAVE HEIGHTS

Q_p = 97,800 − 3,100 CFS = 94,800 CFS
OVER ROAD

$Q = CLH^{3/2} \Rightarrow H = \left(\frac{Q}{CL}\right)^{2/3}$

$H = \left[\frac{94,700\ CFS}{(2.5)(500)}\right]^{2/3} \simeq 18$ Ft.

∴ MAXIMUM FLOOD WAVE IS 32 ft ABOVE STREAM BED OR 18 FEET ABOVE VT 15. DAMAGES = 3 MORE HOMES PLUS JUNK YARD.

BRIDGE FLOW?

$Hw/D = 16/10 = 1.6$, $Q/B = 155$ ★ ∴ $Q = 155 * 20 = 3100$ CFS

OVER BANK FLOW?

$Q = CLH^{3/2} = (2.5)(500\ ft)(2)^{1.5} \simeq 3500$ CFS

TOTAL FLOW? ⇒ 3500 CFS + 3100 CFS ≃ 6600 CFS

6,600 CFS / 86,400 * 100 = 8%, THE SLOPE BETWEEN VT 15 & FARFIELD AVERAGES AT 3.3% OVER 2.5 MILES OF NARROW CHANNEL WITH STEEP BANKS, VERY LITTLE STORAGE.

★ FROM U.S. DEPT. OF TRANSPORTATION, FED. HIGHWAY ADMINISTRATION, HYDRAULIC ENGINEERING. CIRCULAR NO. 5
HYDRAULIC CHARTS FOR THE SELECTION OF HIGHWAY CULVERTS, APRIL 1979.

DUFRESNE-HENRY ENGINEERING CORPORATION

BY M. Root SUBJECT Flood Wave To SHEET NO. 8.1 OF ___
DATE 2-27-80 Village of Morrisville JOB NO. 09-0099

Q_{Peak} for breach at top of dam = 103,000 cfs

Volume of impoundment = 20,360 Ac-ft

Cumulative storage down river to Upper Dam:

Green River Dam to Garfield 982 Ac-ft 98,000 cfs

Garfield to Route 15 (2.5 miles) 2387 Ac-ft [1]

Lamoille River to Morrisville upper dam (4.0 miles) 3830 Ac-ft [2] 66,580 cfs

7,199 Ac-ft

$Q_p = 103{,}000 \left(1 - \frac{7{,}199}{20{,}360}\right)$

$Q_p = 66{,}579$ cfs

[1] Based on average end area:
a.) 9,000 ft² @ Route 15 – 800x15
6,755 ft² @ Garfield
2.5 mile reach → 2387 Ac-ft

[2] Based on 1927 Flood account, see pp. and anticipated excess flood stages; i.e., 2 foot increase.

Average end area of (600' x 18 + 10 x 500) = 7900 ft²

V = 3830 Ac-ft

66,580 cfs flood of dam failure
36,600 cfs 1927 Flood

Morrisville Upper Dam:
spillway widened to 313' after 1927 Flood

$H = \left(\frac{66{,}580}{4.0\ (313)}\right)^{2/3} = 14.1'$ versus 12' in 1927.

ting through Lake Lamoille :

Lake Lamoille 153 Acres

at Cadys Falls ; c = 4.0 ; H = 14' ; L = 175' for Q = 36,600 cfs

First assume $Q_{in} = Q_{out}$

$$H = \left(\frac{66,580}{(4.0)(175)}\right)^{2/3} = 20.8' \qquad \forall = 20.8 \times 153 = 3187 \text{ Ac-ft}$$

$$Q_p = 103,000\left(1 - \frac{7,199 + 3,187}{20,360}\right) = 50,460 \text{ cfs}$$

$H = 17.3'$ $\qquad \forall = 17.3 \times 153 = 2649$ Ac-ft

$$Q_p = 103,000\left(1 - \frac{7,199 + 3,649}{20,360}\right) = 53,180 \text{ cfs}$$

$H = 17.9'$

leaves Cadys Falls at 51,500 cfs $H = 17.6'$ failure of Green River

versus 36,600 cfs $H = 14'$ 1927 Flood

ting to Johnson

6 miles flooded - 5 to 8 feet deep by 1500-2500' wide in 1927

for dam failure - add 3'

use .75 sq. mi. by 9.5' deep = 4560 Ac-ft

$$Q_p = 51,500\left(1 - \frac{4,560}{20,360}\right) = \underline{40,000 \text{ cfs el. } 505}$$

v. 41,800 cfs 1927 Flood

see p. D-8.6 for rating curve.

This floods Village of Johnson by 10-15 feet.

Route to constriction at Ithiel Falls

1 mi.^{2} flooded in 1927 by 10' deep = 6400 Ac-ft

$Q_p = 41,000 \text{ cfs} \left(1 - \frac{6400}{20,360}\right) = 28,100 \text{ CFS}$

El. 495 at Gorge.

Normal water surface = el. 460

1927 Flood = el. 504 or 44' above normal

Dam Failure Flood is 35' above normal in Gorge.

This floods Village of Johnson by (15-9) = 6 feet.

Ithiel Falls to Cambridge Jct.

7.7 miles from Ithiel Falls Gorge

say 5' overbank by 2,000 feet wide = 8,121 Ac-ft.

$Q_p = 28,100 \left(1 - \frac{8121}{20,360}\right) = 16,891 \text{ cfs}$

which is close to channel capacity of

15,500 cfs

∴ close enough considering average flood depths vary from greater than 10' overbank at Gorge exit to almost channel capacity at Cambridge Jct.

4. The rainfall was general over New England, but the brunt of the storm was carried by the State of Vermont, where 6,000 square miles, including the Lamoille Valley above Cambridge, received 6 inches or more of rainfall. (See fig. 1.) Records at Garfield, Vt., show 4.07 inches in 24 hours, with a total of 7.94 inches for the storm period. The maximum observed in Vermont was 9.65 inches at Somerset, of which 8.77 inches occurred in 24 hours. The total rainfall was 9.14 inches at Mollys Falls and 8.66 inches at Northfield. The rainfall in Vermont during the preceding month had been practically double the normal amount. In consequence the ground was saturated and the ponds generally full. This condition was to a certain extent responsible for the high rates of flood run-off.

5. *The effects of the November, 1927, flood.*—(*a*) At East Hardwick about 7 miles below the Passumpsic divide, the channel was insufficient to carry the flood flow, and the water rose several feet over the banks. The foundation of a 75-foot railroad bridge above Hardwick was undermined, and the structure dropped into the river. The water scoured a channel 600 feet long, 200 feet wide, to a depth of 12 to 15 feet.

(*b*) At the village of Hardwick the water flowed over the south wing wall of the lumber mill dam and carried away a large quantity of lumber. Several houses in the path of the water were destroyed, and an acre of land was scoured to a depth of 8 to 10 feet. High water at the Main Street Bridge was just under the bottom chord of the bridge. A part of the dam below the bridge went out, lowering the water through this reach and thereby preventing considerable damage to the business section of the village. Directly below this dam the current eroded the highway for several hundred feet and reduced it to less than 10 feet in width. On Cooper Brook several sections of the railroad were washed out. Water overflowed from Mackville Pond, a power storage reservoir, and dug a ravine 35 to 50 feet in depth and 800 feet in length. Two houses were washed out, and the power plant, then owned by the Woodbury Granite Co., was seriously damaged. At Hardwick Lake water overflowed the wing wall, partly washing it out; undermined the approach to the highway bridge situated about 75 feet below the dam, and finally destroyed the bridge. Below this point high water attained a height of several feet over the banks and spread over a width of five to six hundred feet. A number of bridges were carried away, and the railroad embankment was undermined in many places. The water reached an elevation of 8 feet over the crest of the Hardwick Dam, situated above Wolcott, flooded the power plant, and caused one side of the building to collapse.

(*c*) Between Walcott and Morrisville, two large tributaries, Green River and Wild Brook, enter the main stream. Here the water rose 5 to 10 feet over the banks. Through this reach the flood plain is confined by the narrow valley to an average width of 500 feet. One railroad bridge and three highway bridges were destroyed.

(*d*) The flood waters at the Morrisville power plant overtopped the concrete dam by 12 feet, washing around the north end of the dam and creating a new channel 400 feet wide, 30 feet deep and 1,000 feet long. Six houses were completely destroyed while several others were badly damaged. Directly below, Lake Lamoille was filled to 14 feet above the crest of the dam at Cady's Falls.

(*e*) About 1,200 feet below the dam, a large covered wooden highway bridge went out. From this point for a distance of 6 miles, the low lands were inundated to a depth of 5 to 8 feet, the width varying from 1,500 to 2,500 feet. An area of three-quarters of a square mile was flooded. A half mile above Johnson the river carried away a main stream highway bridge.

(*f*) About 2½ miles below the village of Johnson is located a narrow rock gorge, known locally as Ithiel Falls (Johnson Gorge). At its narrowest point the low-water channel is only 6 feet wide. During the flood this restriction accumulated large quantities of débris which formed an effective barrier to flow. As a result the highest rise on the Lamoille River occurred at this point. The backwater rose rapidly to above 20 feet over the meadows and flooded the village of Johnson to a depth of 10 to 15 feet. Twenty-eight buildings, many of them resisdences, were affected. The flood waters from the gorge to Johnson spread over an area of 1 square mile.

(*g*) Below the gorge the river flows through a long, wide, flat valley past the villages of Jeffersonville and Cambridge to an abrupt fall at Fairfax. This entire valley was inundated to an average depth of 10 feet over the banks and an average width of 1,000 to 3,000 feet. One main highway bridge and the approaches of several others were washed away. Approximately 6 square miles were flooded in this reach.

(*h*) At the Fairfax Falls power plant the water reached a height of 15 feet over the crest of the dam, destroying the highway bridge immediately above. In the next 4 miles to East Georgia the valley is confined to steep banks, and the water rose 19 feet above the river bottom. The highway bridges at both Fairfax and East Georgia were carried away.

(*i*) Between East Georgia and the village of Milton, the valley was inundated to a depth of 12 feet over the banks. The widest expanse of water was 4,000 feet immediately below East Georgia, and above Milton this width was decreased to 1,000 feet. One and a half square miles were flooded.

(*j*) In Milton the current carried away the highway bridge and a number of houses. Above West Milton the narrow valley restricted the waters to a narrow strip, but directly below, a lake was formed, 4,000 feet wide and 10 feet above the banks, over an area of a square mile. About 1,500 feet of the north highway approach at the first bridge above Lake Champlain was washed out.

(*k*) The volume of water temporarily stored in valley storage as the result of insufficient channel capacity is as follows:

	Acre-feet
Below Milton	16,9[illegible]
Milton to Cambridge	32,3[illegible]
Cambridge to Johnson Gorge	24,2[illegible]
Johnson Gorge to Morrisville	21,0[illegible]
Morrisville to 5½ miles above	2,8[illegible]
Total	97,7[illegible]

(1) The total area inundated in the main flood plain from the mouth of the river to the junction with Wild Branch was about 1[illegible] square miles. It is very probable that the flooded lands in the entire basin amounted to 17 square miles, or 2.4 per cent of the total area

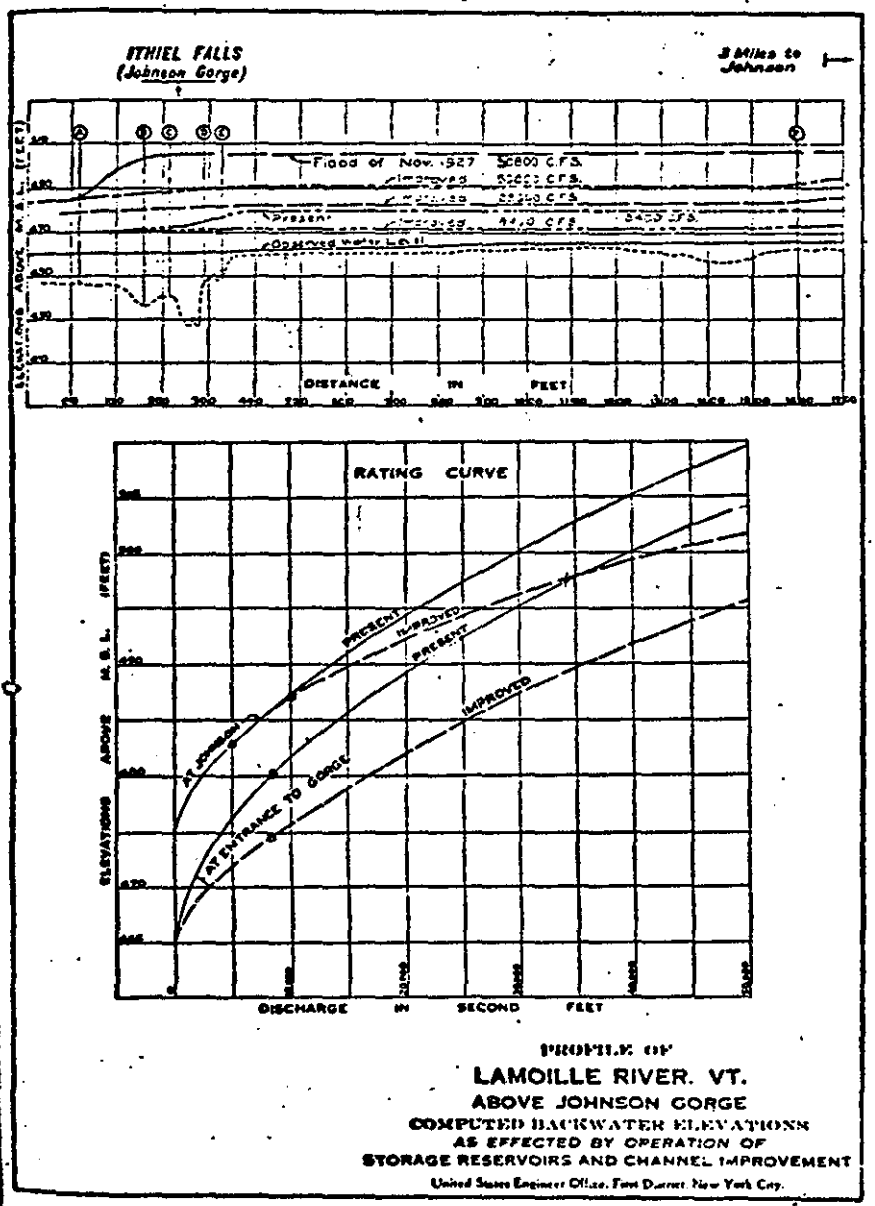
Green River
to
Johnson Gorge

21,025
2,864

23,889 Ac-ft

Dam failure

20,360 Ac-ft



PROFILE OF
LAMOILLE RIVER, VT.
ABOVE JOHNSON GORGE
COMPUTED BACKWATER ELEVATIONS
AS EFFECTED BY OPERATION OF
STORAGE RESERVOIRS AND CHANNEL IMPROVEMENT
United States Engineer Office, First District, New York City.

APPENDIX C—FIGURE 5

From '308' report

TABLE NO. 1.—*Lamoille River, Vt.*

[PRESENT CHANNEL DATA]

Appendix "C"

No.	Location	Miles above mouth of the Lamoille River	Channel capacity	Peak discharge of the 1927 flood	Ratio of Col. (4) to Col. (5)	Concurrent capacity for whole river
1	2	3	4	5	6	7
			Second-feet	*Second-feet*	*Per cent*	*Second-feet*
1	Above mouth of river	2.5	61,400	83,600	73.4	21,500
2	Below village of West Milton	5.5	43,300	83,500	51.9	21,600
3	Above village of West Milton	5.5	31,400	83,500	37.6	21,600
4	Above dam at Milton	9.0	23,500	82,800	28.4	21,500
5	Above highway bridge at Milton	9.4	29,200	82,600	35.4	21,500
6	Above highway bridge at East Georgia	13.0	56,300	80,700	72.5	20,400
7	At village of Fairfax	19.3	19,400	67,500	28.6	17,900
8	Above dam at Fairfax Falls	21.0	20,000	66,900	29.9	16,900
9	Below village of Cambridge	30.0	20,000	63,800	31.4	16,400
10	At village of Cambridge	31.0	16,200	61,500	26.5	16,200
11	Above village of Jeffersonville	34.5	15,500	58,900	26.3	15,400
12	Above Cambridge Junction	35.5	15,200	53,800	28.3	14,900
13	At Johnson Gorge (Ithiel Falls)	43.2	11,000	49,500	24.2	12,800
14	Above dam on Gihon at Johnson	47.0	3,770	14,700	26.0	3,690
15	Main stream at village of Johnson	46.4	14,800	41,800	35.4	12,500
16	Above upper Johnson Gorge	47.3	11,700	41,000	28.5	10,700
17	Below dam at Cadys Falls	54.4	15,600	36,800	42.4	10,500
18	Above dam at Cadys Falls	54.7	21,500	33,100	65.0	9,500
19	Above dam at Morrisville	58.1	19,400	33,000	58.8	9,050
20	Below mouth of Green River	61.2	9,000	28,900	31.1	8,820
21	Above dam at Lake Hardwick	70.7	7,500	15,000	50.0	5,070
22	At village of Hardwick	72.1	4,500	13,500	32.1	4,500
23	Above upper dam at Hardwick	72.3	4,500	13,500	32.1	4,500

e:
key dimensions:

Top of dike : El. 1230

Toe of dike : El. 1210

Water surface - Probable Max. Flood : El. 1230.5

Mid-Height from 1230 to 1210 = El. 1220

length of embankment at el. 1218 = 150'

storage in Green River Reservoir between el. 1210 and 1230

1045 million cubic-feet at 1230 - 525 mcf at 1210 =

Active behind dike: 520,000,000 ft^3 = 11938 Ac-ft
at flood stage

Y_o = 1230.5 - 1210 = 20.5'

V = 11938 Ac-ft

w_b = (.4)(150) = 60 feet

See Hardwick, Hyde Park Quadrangles for wave path of dike

goes first to Zack Woods Pond - elevation 1179 through (15 Acres)
depressions - Perch Pond and Baldin Brook to No Wolcott (6.2 Acres)

depressions are 40' deep - cover - 6 Acres

wave will enter Green River if it exceeds 1205-1210
Garfield to No. Wolcott Rd.

Point of first routing should be outlet of Perch Pond.

Inflow Analysis

Dike failure:

a.) "Flood" stage

$$Q = \frac{8}{27} w_b \sqrt{g}\, Y_o^{3/2} = \frac{8}{27}(60)\sqrt{32.2}\,(20.5)^{3/2} = 9360 \text{ cfs}$$

$V = 11938$ Acre-feet $\qquad \frac{2}{3} Y_o = 13.7'$

b) Maximum recreation pool — spillway crest elevation (1220) "NORMAL"

$$Q = \frac{8}{27}(60)\sqrt{32.2}\,(10)^{3/2} = 3190 \text{ cfs}$$

$\frac{2}{3} Y_o = 6.7'$

$V = 763 \text{ MCF} - 525 \text{ MCF} = 238 \text{ MCF} = 5464$ Ac-ft

Inflow to Zack Woods & Perch Pond adjusted for "depression storage"

Depression storage = $6 \times 40 = 240$ Acre-feet

Flood failure

Pond storage for discharge $\simeq$ 8400 cfs = 24' x 21 Acres = 504 Acre-feet

$$Q_{P_2} = Q_{P_1}\left(1 - \frac{V_1}{S}\right) = 9360\left(1 - \frac{504 - 240}{11938}\right) \simeq .94(9360) = 8800 \text{ CFS}$$

say 8800 cfs inflow to Baldin Brook
1.7 miles to North Wolcott

DUFRESNE-HENRY ENGINEERING CORPORATION

M. Root
10-30-79

SUBJECT Dike Failure
Flood Routing

SHEET NO. 8.9.1 OF ___
JOB NO. 04-0094

al conditions

Depression storage = 290 Ac-ft.

Pond storage = 7' x 21 Acres = 147 Ac-ft.

$$Q_{P_2} = Q_{P_1}\left(1 - \frac{V_1}{S}\right) = 3190\left(1 - \frac{387}{5464}\right) = 2964 \text{ cfs}$$

say $Q \simeq 2800$ cfs

$$\text{drain time} = \frac{238,000,000}{2,800} = 85,000 \text{ sec.} = 1416 \text{ min.} = \underline{\underline{24 \text{ hours}}}$$

N. B. — Volume of water and duration of flow could lead to widening of breach and increase in flow; e.g.,

upper limit would be total loss of berm at lower stage, say 5' over 150' length from $Q = C_L H^{3/2}$

$$Q_{max} = (3.08)(150)(5)^{3/2} = 5165 \text{ cfs}$$

This would pass through Zack Woods without crossing divide into Green River as outlet to Perch Pond has estimated capacity of 5750 cfs at el. 1190±.

Impact of either 2800 cfs or 5200 cfs is subjective based on river channel capacity.

Baldin Bk (2.7 mi²)	1037 csm	1926 csm
Wild Branch (24 mi²)	116 csm	216 csm
Lamoille River (175±)	16 csm	30 csm

DUFRESNE-HENRY ENGINEERING CORPORATION

BY M. Root SUBJECT Dike Failure SHEET NO. 8.9.2 OF ___
DATE 10-30-79 Hydraulic Control at Perch Pond JOB NO. 04-0094

Outlet of Perch Pond-
(best estimate from USGS map)

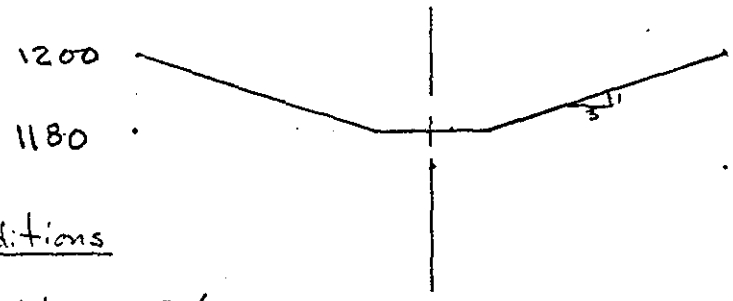
$$Q = CAH^{1/2} = 2.5AH^{1/2}$$

Flood conditions

$H = 13.5$

$A = \left(\frac{121+30}{2}\right)(13.5) = 916.5$ $\quad \hat{Q}_{max} = (2.5)(916.5)(13.5)^{1/2} = 8400$ cfs

say 8800 cfs outflow for failure at test flood (PMF)



Normal conditions

$H = 7'$

$A = \frac{(72+30)}{2}(7) = 357$ $\quad Q = (2.5)(357)(7)^{1/2} = 2361$ cfs

Baldin Brook

1.5 - 1.7 miles to North Wolcott
drops from 1179 to 800

$S_o = 0.0479$; time frame is sufficient to establish normal depth.

Available data for Wild Branch

Cross section	400' downstream of Baldin Brook		Top width	& 1060' above	Top width
stream bed	789.1			799.5	
10-yr flood	796.4	2410 cfs		804.0	
50-yr flood	797.5	4110 cfs		804.8	
100-yr flood	797.8	4930 cfs	335'	805.2	287'
500-yr flood	798.0	7180 cfs		806.7	

DUFRESNE-HENRY ENGINEERING CORPORATION

BY Morris Root SUBJECT Green River SHEET NO. 9 OF
DATE 3-26-80 spillway hydraulics JOB NO. 04-0094.

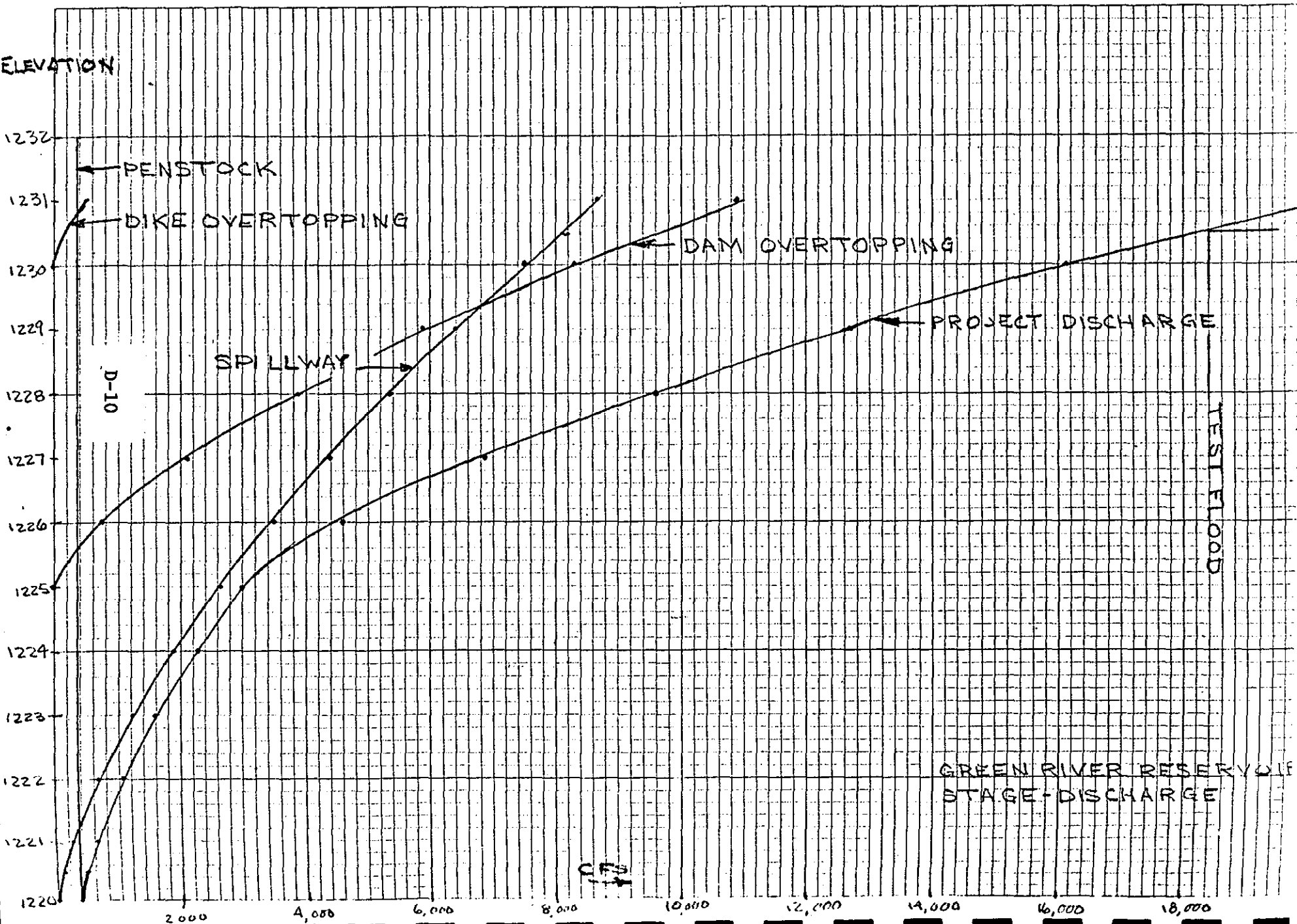
Elevation	Spillway H	Spillway Q	Penstock Q	Dam overtopping H	Dam overtopping Q	Dike H	Dike Q	Total Project
1220.	—	—	373	—	—	—	—	373
1220.5	.5	84		—	—	—	—	457
1221	1.0	237		—	—	—	—	610
1222	2.0	670		—	—	—	—	1043
1223	3.0	1231		—	—	—	—	1604
1224	4.0	1896		—	—	—	—	2269
1225	5.0	2650		—	—	—	—	3023
1226	6.0	3483		1.0	742	—	—	4595
1227	7.0	4389		2.0	2100	—	—	6862
1228	8.0	5363		3.0	3858	—	—	9594
1229	9.0	6399		4.0	5940	—	—	12712
1230	10.0	7495	✓	5.0	8301	—	—	16169
1231	11.0	8696	373	6.0	10912	1.0	507	20438
1232	12.0	9852	373	7.0	13751	2.0	1434	25410

Spillway Flow : $Q = CLH^{3/2} = (3.95)(60)H^{3/2}$

Penstock Flow : Q from published reports = 373 cfs

Dam Overtopping : $Q = CLH^{3/2} = (2.7)(275)H^{3/2}$
effective hydraulic length = 275'
C = 2.7

Dike Overtopping : $Q = CLH^{3/2} = (2.6)(195)H^{3/2}$



BY S.G. FARNSWORTH
DATE 4-5-79

SUBJECT GREEN RIVER RESERVOIR
STAGE - CAPACITY CURVE

SHEET NO. ____ OF ____
JOB NO. 04-0094

BY S.G. FARNSWORTH
DATE 4-5-79

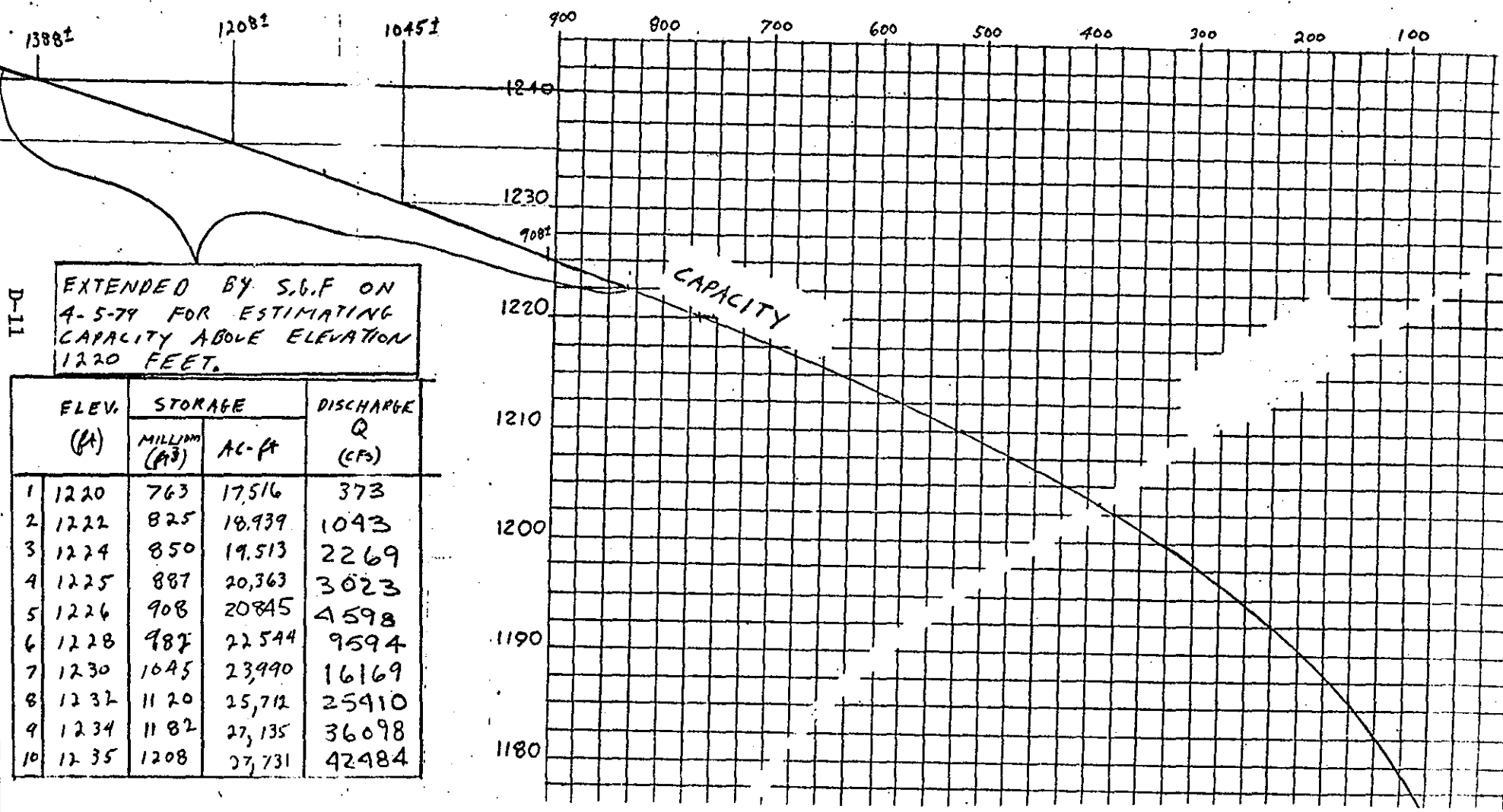
SUBJECT GREEN RIVER RESERVOIR
STAGE - CAPACITY CURVE

SHEET NO. ___ OF ___
JOB NO. 04-0094

EXHIBIT NO. 8 # P. S. COMM.
NOV 14, 1945 U. L. # 2295

COPY FROM PUBLIC SERVIC BOARD
CASE FILE # 2295

CAPACITY IN MILLION CUBIC FEET



EXTENDED BY S.G.F ON 4-5-79 FOR ESTIMATING CAPACITY ABOVE ELEVATION 1220 FEET.

	ELEV. (ft)	STORAGE MILLION (ft^3)	STORAGE AC-ft	DISCHARGE Q (CFS)
1	1220	763	17,516	373
2	1222	825	18.939	1043
3	1224	850	19.513	2269
4	1225	887	20,363	3023
5	1226	908	20845	4598
6	1228	987	22544	9594
7	1230	1045	23,990	16169
8	1232	1120	25,712	25910
9	1234	1182	27, 135	36098
10	1235	1208	27,731	42484

SUB-AREA #	DRAINAGE AREA* IN.²	DRAINAGE AREA* SQ. MI.	LENGTH OF STREAM IN.	LENGTH OF STREAM MILES	L 10% (MINS)	ELEVATIONS @ 10% L (FT)	ELEVATIONS @ 85% L (FT)	S (FT/MI)	Tp (hrs)	REMARKS SOIL	REMARKS T7	REMARKS
1	4.03	3.92	3.6	3.55	.36	1230	1810	218	1.72	C	.12	
2	2.98	2.90	3.6	3.55	.36	1230	1540	135	1.88	C	.12	
3	1.09	1.06	1.3	1.28	.13	1290	1540	260	0.78	C	.12	
4	1.60	1.56	1.8	1.78	.18	1235	1570	251	1.00	C	.12	
5	0.72	0.70	1.2	1.18	.12	1290	1530	328	0.71	C	.12	
6	3.82	3.70	0.6	0.59	.06	1220	1425	463	0.40	C	.12	T_{lag} = .31
		13.84										

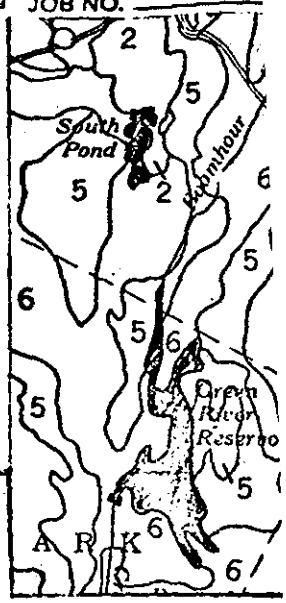
* 1 IN^2 = 0.973 SQ. MI.

$S = (ELEV_{85\%} - ELEV_{10\%}) / (75\% L)$

$L_c = .6L$

$$T_p = 2.2 \left[\frac{L L_c}{\sqrt{S}} \right]^{.37}$$

SCS DATA
CN = 73 FOR II
∴ FOR III, CN = 87
& P = 3.30
PMS = 15
R_6 = 111
R_{12} = 123
R_{24} = 135
105% W.



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GENERAL SOIL MAP

LAMOILLE COUNTY, VERMONT

SOIL ASSOCIATIONS 1/

SOILS THAT FORMED IN WATER-DEPOSITED MATERIAL ON FLOODPLAINS

1 Limerick-Hadley-Winooski association: Deep, level, well drained to poorly drained, silty soils medium in lime; on floodplains subject to flooding

SOILS THAT FORMED IN WATER-DEPOSITED MATERIAL ON TERRACES AND OLD LAKE PLAINS

2 Windsor, gravelly-Windsor association: Deep, level to moderately steep, excessively drained, sandy and gravelly soils low in lime; on terraces along rivers and creeks

3 Hartland association: Deep to moderately deep, gently sloping to sloping, well drained, silty soils medium in lime; on dissected terraces

4 Munson-Buxton-Belgrade association: Deep, gently sloping to steep, moderately well drained and poorly drained, silty and clayey soils medium in lime; on dissected lake plains

SOILS THAT FORMED IN GLACIAL TILL IN THE GREEN MOUNTAINS AND ON UPLANDS

5 Lyman-Marlow-Peru association: Deep and shallow, gently sloping to steep, somewhat excessively drained to moderately well drained, loamy soils low in lime with a hardpan or bedrock within three feet of the surface; on Green Mountains and on uplands

6 Peru-Marlow association: Deep, gently sloping to moderately steep, moderately well drained and well drained, loamy soils low in lime and with a hardpan; on uplands and the Green Mountains

7 Cabot-Peru association: Deep, level to sloping, poorly drained and moderately well drained, loamy soils low in lime and with a hardpan; on uplands and the Green Mountains

SOILS FORMED IN ORGANIC MATERIAL IN DEPRESSIONS

8 Muck and Peat association: Deep, level, very poorly drained, organic soils; in depressions

1/ Texture named in the association refers to dominant texture to a depth of 3 feet.

VERSION DATED JAN 1973
09 AUG 74
MOD. 01

GREEN RIVER RESERVOIR
NEAR MORRISVILLE, VERMONT
FLOOD ROUTING FULL PMF

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
144	0	10	1	0	0	0	2	0	0

JOPER = 3 NMT = 0

SUB-AREA RUNOFF COMPUTATION

SUB-AREA NO.1

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	0	0	0	0	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOR	ISAME	LOCAL
1	1	3.92	0.0	0.0	1.00	0.0	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	15.00	111.00	123.00	135.00	0.0	0.0	0.0

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	0.30	0.12	0.0	0.0

UNIT HYDROGRAPH DATA

TP= 1.72 CP=0.75 NTA= 0

RECESSION DATA

STRTQ= 0.00 QRCSN= -0.10 RTIOR= 1.50

SNYDER CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=12.43 AND R= 6.23 INTERVALS

UNIT HYDROGRAPH 40 END-OF-PERIOD ORDINATES, LAG= 1.71 HOURS, CP= 0.74 VOL= 1.00

36.	134.	266.	415.	571.	729.	881.	1004.	1084.	1124.
1126.	1086.	987.	851.	725.	617.	525.	447.	381.	324.
276.	235.	200.	170.	145.	123.	105.	90.	76.	65.
55.	47.	40.	34.	29.	25.	21.	18.	15.	13.

END-OF-PERIOD FLOW

	TIME	RAIN	EXCS	COMP Q
1	0 10	0.02	0.00	8.
1	0 20	0.02	0.00	7.
1	0 30	0.02	0.00	7.
1	0 40	0.02	0.00	7.
1	0 50	0.02	0.00	7.
1	0 60	0.02	0.00	6.
1	1 10	0.02	0.00	6.
1	1 20	0.02	0.00	6.
1	1 30	0.02	0.00	6.
1	1 40	0.02	0.00	5.
1	1 50	0.02	0.00	5.
1	1 60	0.02	0.00	5.
1	2 10	0.02	0.00	5.
1	2 20	0.02	0.00	5.
1	2 30	0.02	0.00	4.
1	2 40	0.02	0.00	4.
1	2 50	0.02	0.00	4.
1	2 60	0.02	0.00	4.
1	3 10	0.02	0.00	4.
1	3 20	0.02	0.00	4.
1	3 30	0.02	0.00	3.
1	3 40	0.02	0.00	3.
1	3 50	0.02	0.00	3.
1	3 60	0.02	0.00	3.
1	4 10	0.02	0.00	3.
1	4 20	0.02	0.00	3.
1	4 30	0.02	0.00	3.
1	4 40	0.02	0.00	3.
1	4 50	0.02	0.00	2.
1	4 60	0.02	0.00	2.
1	5 10	0.02	0.00	2.
1	5 20	0.02	0.00	2.
1	5 30	0.02	0.00	2.
1	5 40	0.02	0.00	2.
1	5 50	0.02	0.00	2.
1	5 60	0.02	0.00	2.
1	6 10	0.05	0.03	3.

1	6	20	0.05	0.03	7.
1	6	30	0.05	0.03	15.
1	6	40	0.05	0.03	27.
1	6	50	0.05	0.03	44.
1	6	60	0.05	0.03	66.
1	7	10	0.05	0.03	92.
1	7	20	0.05	0.03	122.
1	7	30	0.05	0.03	155.
1	7	40	0.05	0.03	189.
1	7	50	0.05	0.03	222.
1	7	60	0.05	0.03	255.
1	8	10	0.05	0.03	284.
1	8	20	0.05	0.03	310.
1	8	30	0.05	0.03	332.
1	8	40	0.05	0.03	350.
1	8	50	0.05	0.03	366.
1	8	60	0.05	0.03	379.
1	9	10	0.05	0.03	391.
1	9	20	0.05	0.03	400.
1	9	30	0.05	0.03	408.
1	9	40	0.05	0.03	415.
1	9	50	0.05	0.03	421.
1	9	60	0.05	0.03	427.
1	10	10	0.05	0.03	431.
1	10	20	0.05	0.03	435.
1	10	30	0.05	0.03	438.
1	10	40	0.05	0.03	440.
1	10	50	0.05	0.03	443.
1	10	60	0.05	0.03	445.
1	11	10	0.05	0.03	446.
1	11	20	0.05	0.03	448.
1	11	30	0.05	0.03	449.
1	11	40	0.05	0.03	450.
1	11	50	0.05	0.03	451.
1	11	60	0.05	0.03	451.
1	12	10	0.28	0.26	460.
1	12	20	0.28	0.26	491.
1	12	30	0.28	0.26	552.
1	12	40	0.28	0.26	647.
1	12	50	0.28	0.26	777.
1	12	60	0.28	0.26	943.
1	13	10	0.33	0.31	1145.
1	13	20	0.33	0.31	1381.
1	13	30	0.33	0.31	1642.
1	13	40	0.33	0.31	1921.
1	13	50	0.33	0.31	2209.
1	13	60	0.33	0.31	2496.
1	14	10	0.42	0.40	2773.
1	14	20	0.42	0.40	3033.
1	14	30	0.42	0.40	3280.
1	14	40	0.42	0.40	3518.
1	14	50	0.42	0.40	3747.
1	14	60	0.42	0.40	3970.
1	15	10	1.05	1.03	4208.
1	15	20	1.05	1.03	4498.
1	15	30	1.05	1.03	4861.
1	15	40	1.05	1.03	5307.
1	15	50	1.05	1.03	5840.
1	15	60	1.05	1.03	6459.
1	16	10	0.39	0.37	7134.
1	16	20	0.39	0.37	7802.
1	16	30	0.39	0.37	8416.
1	16	40	0.39	0.37	8942.
1	16	50	0.39	0.37	9352.
1	16	60	0.39	0.37	9621.
1	17	10	0.31	0.29	9714.
1	17	20	0.31	0.29	9622.
1	17	30	0.31	0.29	9378.
1	17	40	0.31	0.29	9021.
1	17	50	0.31	0.29	8587.
1	17	60	0.31	0.29	8111.
1	18	10	0.03	0.01	7633.
1	18	20	0.03	0.01	7170.
1	18	30	0.03	0.01	6714.
1	18	40	0.03	0.01	6258.
1	18	50	0.03	0.01	5793.
1	18	60	0.03	0.01	5320.
1	19	10	0.03	0.01	4840.
1	19	20	0.03	0.01	4360.
1	19	30	0.03	0.01	3889.
1	19	40	0.03	0.01	3433.
1	19	50	0.03	0.01	2997.
1	19	60	0.03	0.01	2591.
1	20	10	0.03	0.01	2228.
1	20	20	0.03	0.01	1916.
1	20	30	0.03	0.01	1650.
1	20	40	0.03	0.01	1424.

1	20	50	0.03	0.01	1231.
1	20	60	0.03	0.01	1066.
1	21	10	0.03	0.01	959.
1	21	20	0.03	0.01	921.
1	21	30	0.03	0.01	884.
1	21	40	0.03	0.01	849.
1	21	50	0.03	0.01	815.
1	21	60	0.03	0.01	783.
1	22	10	0.03	0.01	752.
1	22	20	0.03	0.01	722.
1	22	30	0.03	0.01	693.
1	22	40	0.03	0.01	666.
1	22	50	0.03	0.01	639.
1	23	60	0.03	0.01	614.
1	23	10	0.03	0.01	589.
1	23	20	0.03	0.01	566.
1	23	30	0.03	0.01	544.
1	23	40	0.03	0.01	522.
1	23	50	0.03	0.01	501.
1	23	60	0.03	0.01	481.
		SUM	20.28	17.40	266027.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9714.	6061.	1847.	1847.	266023.
INCHES		14.38	17.54	17.54	17.54
AC-FT		3007.	3665.	3666.	3666.

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SUB-AREA RUNOFF COMPUTATION

SUB-AREA NO.2

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
2	0	0	0	0	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	2.90	0.0	0.0	1.00	0.0	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	15.00	111.00	123.00	135.00	0.0	0.0	0.0

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	0.30	0.12	0.0	0.0

UNIT HYDROGRAPH DATA

TP# 1.88 CP#0.75 NTA# 0

RECESSION DATA

STRTQ# 6.00 QRCSN# -0.10 RTIOR# 1.50

THE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC#13.36 AND R# 6.97 INTERVALS

UNIT HYDROGRAPH 45 END-OF-PERIOD ORDINATES, LAG# 1.87 HOURS, CP# 0.74 VOL# 1.00

22.	80.	161.	252.	348.	447.	546.	634.	700.	742.
762.	760.	733.	670.	585.	507.	439.	380.	329.	285.
247.	214.	185.	160.	139.	120.	104.	90.	78.	68.
59.	51.	44.	38.	33.	29.	25.	21.	19.	16.
14.	12.	10.	9.	8.					

END-OF-PERIOD FLOW

		TIME	RAIN	EXCS	COMP Q
1	0	10	0.02	0.00	6.
1	0	20	0.02	0.00	6.
1	0	30	0.02	0.00	5.
1	0	40	0.02	0.00	5.
1	0	50	0.02	0.00	5.
1	0	60	0.02	0.00	5.
1	1	10	0.02	0.00	5.
1	1	20	0.02	0.00	4.
1	1	30	0.02	0.00	4.
1	1	40	0.02	0.00	4.
1	1	50	0.02	0.00	4.
1	1	60	0.02	0.00	4.
1	2	10	0.02	0.00	4.
1	2	20	0.02	0.00	3.
1	2	30	0.02	0.00	3.
1	2	40	0.02	0.00	3.
1	2	50	0.02	0.00	3.
1	2	60	0.02	0.00	3.
1	3	10	0.02	0.00	3.
1	3	20	0.02	0.00	3.
1	3	30	0.02	0.00	3.
1	3	40	0.02	0.00	2.
1	3	50	0.02	0.00	2.

1	3	60	0.02	0.00	2.
1	4	10	0.02	0.00	2.
1	4	20	0.02	0.00	2.
1	4	30	0.02	0.00	2.
1	4	40	0.02	0.00	2.
1	4	50	0.02	0.00	2.
1	4	60	0.02	0.00	2.
1	5	10	0.02	0.00	2.
1	5	20	0.02	0.00	2.
1	5	30	0.02	0.00	2.
1	5	40	0.02	0.00	2.
1	5	50	0.02	0.00	1.
1	5	60	0.02	0.00	1.
1	6	10	0.05	0.03	2.
1	6	20	0.05	0.03	4.
1	6	30	0.05	0.03	9.
1	6	40	0.05	0.03	17.
1	6	50	0.05	0.03	27.
1	6	60	0.05	0.03	40.
1	7	10	0.05	0.03	57.
1	7	20	0.05	0.03	76.
1	7	30	0.05	0.03	97.
1	7	40	0.05	0.03	119.
1	7	50	0.05	0.03	142.
1	7	50	0.05	0.03	164.
1	8	10	0.05	0.03	186.
1	8	20	0.05	0.03	206.
1	8	30	0.05	0.03	224.
1	8	40	0.05	0.03	239.
1	8	50	0.05	0.03	252.
1	8	60	0.05	0.03	264.
1	9	10	0.05	0.03	274.
1	9	20	0.05	0.03	282.
1	9	30	0.05	0.03	289.
1	9	40	0.05	0.03	296.
1	9	50	0.05	0.03	301.
1	9	60	0.05	0.03	306.
1	10	10	0.05	0.03	310.
1	10	20	0.05	0.03	314.
1	10	30	0.05	0.03	317.
1	10	40	0.05	0.03	320.
1	10	50	0.05	0.03	322.
1	10	60	0.05	0.03	324.
1	11	10	0.05	0.03	326.
1	11	20	0.05	0.03	327.
1	11	30	0.05	0.03	329.
1	11	40	0.05	0.03	330.
1	11	50	0.05	0.03	331.
1	11	60	0.05	0.03	331.
1	12	10	0.28	0.26	337.
1	12	20	0.28	0.26	356.
1	12	30	0.28	0.26	393.
1	12	40	0.28	0.26	451.
1	12	50	0.28	0.26	530.
1	12	60	0.28	0.26	632.
1	13	10	0.33	0.31	758.
1	13	20	0.33	0.31	907.
1	13	30	0.33	0.31	1075.
1	13	40	0.33	0.31	1258.
1	13	50	0.33	0.31	1451.
1	13	60	0.33	0.31	1649.
1	14	10	0.42	0.40	1847.
1	14	20	0.42	0.40	2042.
1	14	30	0.42	0.40	2227.
1	14	40	0.42	0.40	2404.
1	14	50	0.42	0.40	2575.
1	14	60	0.42	0.40	2741.
1	15	10	1.05	1.03	2916.
1	15	20	1.05	1.03	3122.
1	15	30	1.05	1.03	3372.
1	15	40	1.05	1.03	3671.
1	15	50	1.05	1.03	4023.
1	15	60	1.05	1.03	4429.
1	16	10	0.39	0.37	4873.
1	16	20	0.39	0.37	5324.
1	16	30	0.39	0.37	5749.
1	16	40	0.39	0.37	6130.
1	16	50	0.39	0.37	6450.
1	16	60	0.39	0.37	6693.
1	17	10	0.31	0.29	6844.
1	17	20	0.31	0.29	6884.
1	17	30	0.31	0.29	6814.
1	17	40	0.31	0.29	6654.
1	17	50	0.31	0.29	6424.
1	17	60	0.31	0.29	6147.
1	18	10	0.03	0.01	5838.
1	18	20	0.03	0.01	5517.
1	18	30	0.03	0.01	5198.
1	18	40	0.03	0.01	4879.
1	18	50	0.03	0.01	4557.

1	18	60	0.03	0.01	4230.
1	19	10	0.03	0.01	3897.
1	19	20	0.03	0.01	3561.
1	19	30	0.03	0.01	3228.
1	19	40	0.03	0.01	2901.
1	19	50	0.03	0.01	2585.
1	19	60	0.03	0.01	2283.
1	20	10	0.03	0.01	2002.
1	20	20	0.03	0.01	1748.
1	20	30	0.03	0.01	1527.
1	20	40	0.03	0.01	1336.
1	20	50	0.03	0.01	1170.
1	20	60	0.03	0.01	1026.
1	21	10	0.03	0.01	901.
1	21	20	0.03	0.01	794.
1	21	30	0.03	0.01	700.
1	21	40	0.03	0.01	665.
1	21	50	0.03	0.01	639.
1	21	60	0.03	0.01	613.
1	22	10	0.03	0.01	589.
1	22	20	0.03	0.01	565.
1	22	30	0.03	0.01	543.
1	22	40	0.03	0.01	521.
1	22	50	0.03	0.01	501.
1	22	60	0.03	0.01	481.
1	23	10	0.03	0.01	462.
1	23	20	0.03	0.01	443.
1	23	30	0.03	0.01	426.
1	23	40	0.03	0.01	409.
1	23	50	0.03	0.01	393.
1	23	60	0.03	0.01	377.
		SUM	20.28	17.40	195524.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	6884.	4422.	1358.	1358.	195522.
INCHES		14.18	17.42	17.42	17.42
AC-FT		2194.	2695.	2695.	2695.

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SUB-AREA RUNOFF COMPUTATION

SUB-AREA NO.3

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
3	0	0	0	0	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	1.08	0.0	0.0	1.00	0.0	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	15.00	111.00	123.00	135.00	0.0	0.0	0.0

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	0.30	0.12	0.0	0.0

UNIT HYDROGRAPH DATA

TP= 0.78 CP=0.75 NTA= 0

RECESSION DATA

STRTQ= 2.00 QRCSN= -0.10 RTIOR= 1.50

IF CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 5.79 AND R= 2.86 INTERVALS

UNIT HYDROGRAPH 19 END-OF-PERIOD ORDINATES, LAG= 0.78 HOURS, CP= 0.74 VOL= 1.00

62.	219.	413.	577.	650.	605.	469.	329.	231.	163.
114.	80.	56.	40.	28.	20.	14.	10.	7.	

END-OF-PERIOD FLOW

		TIME	RAIN	EXCS	COMP Q
1	0	10	0.02	0.00	2.
1	0	20	0.02	0.00	2.
1	0	30	0.02	0.00	2.
1	0	40	0.02	0.00	2.
1	0	50	0.02	0.00	2.
1	0	60	0.02	0.00	2.
1	1	10	0.02	0.00	2.
1	1	20	0.02	0.00	1.
1	1	30	0.02	0.00	1.
1	1	40	0.02	0.00	1.
1	1	50	0.02	0.00	1.
1	1	60	0.02	0.00	1.
1	2	10	0.02	0.00	1.
1	2	20	0.02	0.00	1.

1	2	30	0.02	0.00	1.
1	2	40	0.02	0.00	1.
1	2	50	0.02	0.00	1.
1	2	60	0.02	0.00	1.
1	3	10	0.02	0.00	1.
1	3	20	0.02	0.00	1.
1	3	30	0.02	0.00	1.
1	3	40	0.02	0.00	1.
1	3	50	0.02	0.00	1.
1	3	60	0.02	0.00	1.
1	4	10	0.02	0.00	1.
1	4	20	0.02	0.00	1.
1	4	30	0.02	0.00	1.
1	4	40	0.02	0.00	1.
1	4	50	0.02	0.00	1.
1	4	60	0.02	0.00	1.
1	5	10	0.02	0.00	1.
1	5	20	0.02	0.00	1.
1	5	30	0.02	0.00	1.
1	5	40	0.02	0.00	1.
1	5	50	0.02	0.00	0.
1	5	60	0.02	0.00	0.
1	6	10	0.05	0.03	2.
1	6	20	0.05	0.03	9.
1	6	30	0.05	0.03	21.
1	6	40	0.05	0.03	39.
1	6	50	0.05	0.03	58.
1	6	60	0.05	0.03	76.
1	7	10	0.05	0.03	90.
1	7	20	0.05	0.03	100.
1	7	30	0.05	0.03	107.
1	7	40	0.05	0.03	112.
1	7	50	0.05	0.03	115.
1	7	60	0.05	0.03	118.
1	8	10	0.05	0.03	119.
1	8	20	0.05	0.03	121.
1	8	30	0.05	0.03	121.
1	8	40	0.05	0.03	122.
1	8	50	0.05	0.03	122.
1	8	60	0.05	0.03	123.
1	9	10	0.05	0.03	123.
1	9	20	0.05	0.03	123.
1	9	30	0.05	0.03	123.
1	9	40	0.05	0.03	123.
1	9	50	0.05	0.03	123.
1	9	60	0.05	0.03	123.
1	10	10	0.05	0.03	123.
1	10	20	0.05	0.03	123.
1	10	30	0.05	0.03	123.
1	10	40	0.05	0.03	123.
1	10	50	0.05	0.03	123.
1	10	60	0.05	0.03	123.
1	11	10	0.05	0.03	123.
1	11	20	0.05	0.03	123.
1	11	30	0.05	0.03	123.
1	11	40	0.05	0.03	123.
1	11	50	0.05	0.03	123.
1	11	60	0.05	0.03	123.
1	12	10	0.28	0.26	137.
1	12	20	0.28	0.26	187.
1	12	30	0.28	0.26	281.
1	12	40	0.28	0.26	412.
1	12	50	0.28	0.26	560.
1	12	60	0.28	0.26	697.
1	13	10	0.33	0.31	808.
1	13	20	0.33	0.31	895.
1	13	30	0.33	0.31	970.
1	13	40	0.33	0.31	1039.
1	13	50	0.33	0.31	1101.
1	13	60	0.33	0.31	1153.
1	14	10	0.42	0.40	1197.
1	14	20	0.42	0.40	1242.
1	14	30	0.42	0.40	1296.
1	14	40	0.42	0.40	1358.
1	14	50	0.42	0.40	1421.
1	14	60	0.42	0.40	1478.
1	15	10	1.05	1.03	1561.
1	15	20	1.05	1.03	1731.
1	15	30	1.05	1.03	2015.
1	15	40	1.05	1.03	2398.
1	15	50	1.05	1.03	2823.
1	15	60	1.05	1.03	3217.
1	16	10	0.39	0.37	3480.
1	16	20	0.39	0.37	3548.
1	16	30	0.39	0.37	3422.
1	16	40	0.39	0.37	3144.
1	16	50	0.39	0.37	2784.
1	16	60	0.39	0.37	2433.
1	17	10	0.31	0.29	2152.
1	17	20	0.31	0.29	1940.

1	17 30	0.31	0.29	1770.
1	17 40	0.31	0.29	1626.
1	17 50	0.31	0.29	1504.
1	17 60	0.31	0.29	1407.
1	18 10	0.03	0.01	1317.
1	18 20	0.03	0.01	1203.
1	18 30	0.03	0.01	1052.
1	18 40	0.03	0.01	867.
1	18 50	0.03	0.01	669.
1	18 60	0.03	0.01	489.
1	19 10	0.03	0.01	354.
1	19 20	0.03	0.01	340.
1	19 30	0.03	0.01	327.
1	19 40	0.03	0.01	314.
1	19 50	0.03	0.01	301.
1	19 60	0.03	0.01	289.
1	20 10	0.03	0.01	278.
1	20 20	0.03	0.01	267.
1	20 30	0.03	0.01	256.
1	20 40	0.03	0.01	246.
1	20 50	0.03	0.01	236.
1	20 60	0.03	0.01	227.
1	21 10	0.03	0.01	218.
1	21 20	0.03	0.01	209.
1	21 30	0.03	0.01	201.
1	21 40	0.03	0.01	193.
1	21 50	0.03	0.01	185.
1	21 60	0.03	0.01	178.
1	22 10	0.03	0.01	171.
1	22 20	0.03	0.01	164.
1	22 30	0.03	0.01	157.
1	22 40	0.03	0.01	151.
1	22 50	0.03	0.01	145.
1	22 60	0.03	0.01	139.
1	23 10	0.03	0.01	134.
1	23 20	0.03	0.01	129.
1	23 30	0.03	0.01	123.
1	23 40	0.03	0.01	119.
1	23 50	0.03	0.01	114.
1	23 60	0.03	0.01	109.
	SUM	20.28	17.40	74888.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3548.	1742.	520.	520.	74880.
INCHES		15.29	18.25	18.25	18.25
AC-FT		864.	1032.	1032.	1032.

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SUB-AREA RUNOFF COMPUTATION

SUB-AREA NO.4

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
4	0	0	0	0	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	1.56	0.0	0.0	1.00	0.0	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	15.00	111.00	123.00	135.00	0.0	0.0	0.0

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	0.30	0.12	0.0	0.0

UNIT HYDROGRAPH DATA

TP# 1.00 CP#0.75 NTA# 0

RECESSION DATA

STRTQ# 3.00 QRCSN# -0.10 RTIOR# 1.50

MATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC# 7.31 AND R# 3.65 INTERVALS

UNIT HYDROGRAPH 24 END-OF-PERIOD ORDINATES, LAG# 0.99 HOURS, CP# 0.74 VOL# 1.00

52.	187.	360.	540.	684.	755.	747.	645.	498.	378.
287.	218.	165.	125.	95.	72.	55.	42.	32.	24.
18.	14.	10.	8.						

END-OF-PERIOD FLOW

	TIME	RAIN	EXCS	COMP Q.
1	0 10	0.02	0.00	3.
1	0 20	0.02	0.00	3.
1	0 30	0.02	0.00	3.
1	0 40	0.02	0.00	3.
1	0 50	0.02	0.00	2.
1	0 60	0.02	0.00	2.
1	1 10	0.02	0.00	2.
1	1 20	0.02	0.00	2.
1	1 30	0.02	0.00	2.
1	1 40	0.02	0.00	2.
1	1 50	0.02	0.00	2.
1	1 60	0.02	0.00	2.
1	2 10	0.02	0.00	2.
1	2 20	0.02	0.00	2.
1	2 30	0.02	0.00	2.
1	2 40	0.02	0.00	2.
1	2 50	0.02	0.00	2.
1	2 60	0.02	0.00	1.
1	3 10	0.02	0.00	1.
1	3 20	0.02	0.00	1.
1	3 30	0.02	0.00	1.
1	3 40	0.02	0.00	1.
1	3 50	0.02	0.00	1.
1	3 60	0.02	0.00	1.
1	4 10	0.02	0.00	1.
1	4 20	0.02	0.00	1.
1	4 30	0.02	0.00	1.
1	4 40	0.02	0.00	1.
1	4 50	0.02	0.00	1.
1	4 60	0.02	0.00	1.
1	5 10	0.02	0.00	1.
1	5 20	0.02	0.00	1.
1	5 30	0.02	0.00	1.
1	5 40	0.02	0.00	1.
1	5 50	0.02	0.00	1.
1	5 60	0.02	0.00	1.
1	6 10	0.05	0.03	2.
1	6 20	0.05	0.03	8.
1	6 30	0.05	0.03	19.
1	6 40	0.05	0.03	35.
1	6 50	0.05	0.03	55.
1	6 60	0.05	0.03	78.
1	7 10	0.05	0.03	100.
1	7 20	0.05	0.03	120.
1	7 30	0.05	0.03	135.
1	7 40	0.05	0.03	146.
1	7 50	0.05	0.03	154.
1	7 60	0.05	0.03	161.
1	8 10	0.05	0.03	166.
1	8 20	0.05	0.03	170.
1	8 30	0.05	0.03	173.
1	8 40	0.05	0.03	175.
1	8 50	0.05	0.03	176.
1	8 60	0.05	0.03	178.
1	9 10	0.05	0.03	178.
1	9 20	0.05	0.03	179.
1	9 30	0.05	0.03	180.
1	9 40	0.05	0.03	180.
1	9 50	0.05	0.03	180.
1	9 60	0.05	0.03	181.
1	10 10	0.05	0.03	181.
1	10 20	0.05	0.03	181.
1	10 30	0.05	0.03	181.
1	10 40	0.05	0.03	181.
1	10 50	0.05	0.03	181.
1	10 60	0.05	0.03	181.
1	11 10	0.05	0.03	181.
1	11 20	0.05	0.03	181.
1	11 30	0.05	0.03	181.
1	11 40	0.05	0.03	181.
1	11 50	0.05	0.03	181.
1	11 60	0.05	0.03	181.
1	12 10	0.28	0.26	192.
1	12 20	0.28	0.26	235.
1	12 30	0.28	0.26	317.
1	12 40	0.28	0.26	440.
1	12 50	0.28	0.26	595.
1	12 60	0.28	0.26	767.
1	13 10	0.33	0.31	940.
1	13 20	0.33	0.31	1097.
1	13 30	0.33	0.31	1230.
1	13 40	0.33	0.31	1346.
1	13 50	0.33	0.31	1450.
1	13 60	0.33	0.31	1541.
1	14 10	0.42	0.40	1624.

1	14	20	0.42	0.40	1704.
1	14	30	0.42	0.40	1784.
1	14	40	0.42	0.40	1866.
1	14	50	0.42	0.40	1951.
1	14	60	0.42	0.40	2036.
1	15	10	1.05	1.03	2148.
1	15	20	1.05	1.03	2333.
1	15	30	1.05	1.03	2614.
1	15	40	1.05	1.03	2997.
1	15	50	1.05	1.03	3463.
1	15	60	1.05	1.03	3968.
1	16	10	0.39	0.37	4425.
1	16	20	0.39	0.37	4724.
1	16	30	0.39	0.37	4811.
1	16	40	0.39	0.37	4699.
1	16	50	0.39	0.37	4431.
1	16	60	0.39	0.37	4071.
1	17	10	0.31	0.29	3678.
1	17	20	0.31	0.29	3315.
1	17	30	0.31	0.29	3016.
1	17	40	0.31	0.29	2766.
1	17	50	0.31	0.29	2554.
1	17	60	0.31	0.29	2373.
1	18	10	0.03	0.01	2207.
1	18	20	0.03	0.01	2033.
1	18	30	0.03	0.01	1841.
1	18	40	0.03	0.01	1621.
1	18	50	0.03	0.01	1379.
1	18	60	0.03	0.01	1131.
1	19	10	0.03	0.01	890.
1	19	20	0.03	0.01	687.
1	19	30	0.03	0.01	529.
1	19	40	0.03	0.01	470.
1	19	50	0.03	0.01	451.
1	19	60	0.03	0.01	433.
1	20	10	0.03	0.01	416.
1	20	20	0.03	0.01	399.
1	20	30	0.03	0.01	383.
1	20	40	0.03	0.01	368.
1	20	50	0.03	0.01	354.
1	20	60	0.03	0.01	340.
1	21	10	0.03	0.01	326.
1	21	20	0.03	0.01	313.
1	21	30	0.03	0.01	301.
1	21	40	0.03	0.01	289.
1	21	50	0.03	0.01	277.
1	21	60	0.03	0.01	266.
1	22	10	0.03	0.01	256.
1	22	20	0.03	0.01	246.
1	22	30	0.03	0.01	236.
1	22	40	0.03	0.01	226.
1	22	50	0.03	0.01	217.
1	22	60	0.03	0.01	209.
1	23	10	0.03	0.01	200.
1	23	20	0.03	0.01	192.
1	23	30	0.03	0.01	185.
1	23	40	0.03	0.01	177.
1	23	50	0.03	0.01	170.
1	23	60	0.03	0.01	164.
		SUM	20.28	17.40	109041.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4811.	2532.	757.	757.	109034.
INCHES		15.10	18.06	18.06	18.06
AC-FT		1256.	1503.	1503.	1503.

OVN*

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SUB-AREA RUNOFF COMPUTATION

SUB-AREA NO.5

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	JNAME
5	0	0	0	0	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	0.70	0.0	0.9	1.00	0.0	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	15.00	111.00	123.00	135.00	0.0	0.0	0.0

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	0.30	0.12	0.0	0.0

UNIT HYDROGRAPH DATA

TP# 0.71 CP#0.75 NTA# 0

RECESSION DATA

STRTQ# 2.00 QRCSN# -0.10 RTIOR# 1.50

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC# 5.61 AND R# 2.41 INTERVALS

UNIT HYDROGRAPH 16 END-OF-PERIOD ORDINATES, LAG# 0.71 HOURS, CP# 0.75 VOL# 1.00

49.	172.	320.	434.	470.	410.	293.	192.	126.	83.
54.	36.	23.	15.	10.	7.				

END-OF-PERIOD FLOW

	TIME	RAIN	EXCS	COMP Q
1	0 10	0.02	0.00	2.
1	0 20	0.02	0.00	2.
1	0 30	0.02	0.00	2.
1	0 40	0.02	0.00	2.
1	0 50	0.02	0.00	2.
1	0 60	0.02	0.00	2.
1	1 10	0.02	0.00	2.
1	1 20	0.02	0.00	1.
1	1 30	0.02	0.00	1.
1	1 40	0.02	0.00	1.
1	1 50	0.02	0.00	1.
1	1 60	0.02	0.00	1.
1	2 10	0.02	0.00	1.
1	2 20	0.02	0.00	1.
1	2 30	0.02	0.00	1.
1	2 40	0.02	0.00	1.
1	2 50	0.02	0.00	1.
1	2 60	0.02	0.00	1.
1	3 10	0.02	0.00	1.
1	3 20	0.02	0.00	1.
1	3 30	0.02	0.00	1.
1	3 40	0.02	0.00	1.
1	3 50	0.02	0.00	1.
1	3 60	0.02	0.00	1.
1	4 10	0.02	0.00	1.
1	4 20	0.02	0.00	1.
1	4 30	0.02	0.00	1.
1	4 40	0.02	0.00	1.
1	4 50	0.02	0.00	1.
1	4 60	0.02	0.00	1.
1	5 10	0.02	0.00	1.
1	5 20	0.02	0.00	1.
1	5 30	0.02	0.00	1.
1	5 40	0.02	0.00	1.
1	5 50	0.02	0.00	0.
1	5 60	0.02	0.00	0.
1	6 10	0.05	0.03	2.
1	6 20	0.05	0.03	7.
1	6 30	0.05	0.03	17.
1	6 40	0.05	0.03	30.
1	6 50	0.05	0.03	44.
1	6 60	0.05	0.03	56.
1	7 10	0.05	0.03	65.
1	7 20	0.05	0.03	71.
1	7 30	0.05	0.03	74.
1	7 40	0.05	0.03	77.
1	7 50	0.05	0.03	78.
1	7 60	0.05	0.03	80.
1	8 10	0.05	0.03	80.
1	8 20	0.05	0.03	81.

1	8	30	0.05	0.03	81.
1	8	40	0.05	0.03	81.
1	8	50	0.05	0.03	81.
1	8	60	0.05	0.03	81.
1	9	10	0.05	0.03	81.
1	9	20	0.05	0.03	81.
1	9	30	0.05	0.03	81.
1	9	40	0.05	0.03	81.
1	9	50	0.05	0.03	81.
1	9	60	0.05	0.03	81.
1	10	10	0.05	0.03	81.
1	10	20	0.05	0.03	81.
1	10	30	0.05	0.03	81.
1	10	40	0.05	0.03	81.
1	10	50	0.05	0.03	81.
1	10	60	0.05	0.03	81.
1	11	10	0.05	0.03	81.
1	11	20	0.05	0.03	81.
1	11	30	0.05	0.03	81.
1	11	40	0.05	0.03	81.
1	11	50	0.05	0.03	81.
1	11	60	0.05	0.03	81.
1	12	10	0.28	0.26	92.
1	12	20	0.28	0.26	131.
1	12	30	0.28	0.26	204.
1	12	40	0.28	0.26	303.
1	12	50	0.28	0.26	410.
1	12	60	0.28	0.26	503.
1	13	10	0.33	0.31	572.
1	13	20	0.33	0.31	626.
1	13	30	0.33	0.31	672.
1	13	40	0.33	0.31	715.
1	13	50	0.33	0.31	754.
1	13	60	0.33	0.31	785.
1	14	10	0.42	0.40	810.
1	14	20	0.42	0.40	839.
1	14	30	0.42	0.40	875.
1	14	40	0.42	0.40	917.
1	14	50	0.42	0.40	959.
1	14	60	0.42	0.40	995.
1	15	10	1.05	1.03	1053.
1	15	20	1.05	1.03	1179.

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SUB-AREA RUNOFF COMPUTATION

SUB-AREA NO.6

ISTAG	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
6	0	0	0	0	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	3.70	0.0	0.0	1.00	0.0	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	15.00	111.00	123.00	135.00	0.0	0.0	0.0

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	0.30	0.12	0.0	0.0

UNIT HYDROGRAPH DATA

TP= 0.40 CP=0.75 NTA= 0

RECESSION DATA

STRTQ= 8.00 QRCSN= -0.10 RTIOR= 1.50

CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 3.14 AND R= 1.39 INTERVALS

UNIT HYDROGRAPH 9 END-OF-PERIOD ORDINATES, LAG= 0.40 HOURS, CP= 0.75 VOL= 1.00

959. 3061. 4215. 3163. 1544. 728. 343. 162. 76.

END-OF-PERIOD FLOW

	TIME	RAIN	EXCS	COMP Q
1	0 10	0.02	0.00	8.
1	0 20	0.02	0.00	7.
1	0 30	0.02	0.00	7.
1	0 40	0.02	0.00	7.
1	0 50	0.02	0.00	7.
1	0 60	0.02	0.00	6.
1	1 10	0.02	0.00	6.
1	1 20	0.02	0.00	6.
1	1 30	0.02	0.00	6.

1	1	40	0.02	0.00	5.
1	1	50	0.02	0.00	5.
1	1	60	0.02	0.00	5.
1	2	10	0.02	0.00	5.
1	2	20	0.02	0.00	5.
1	2	30	0.02	0.00	4.
1	2	40	0.02	0.00	4.
1	2	50	0.02	0.00	4.
1	2	60	0.02	0.00	4.
1	3	10	0.02	0.00	4.
1	3	20	0.02	0.00	4.
1	3	30	0.02	0.00	3.
1	3	40	0.02	0.00	3.
1	3	50	0.02	0.00	3.
1	3	60	0.02	0.00	3.
1	4	10	0.02	0.00	3.
1	4	20	0.02	0.00	3.
1	4	30	0.02	0.00	3.
1	4	40	0.02	0.00	3.
1	4	50	0.02	0.00	2.
1	4	60	0.02	0.00	2.
1	5	10	0.02	0.00	2.
1	5	20	0.02	0.00	2.
1	5	30	0.02	0.00	2.
1	5	40	0.02	0.00	2.
1	5	50	0.02	0.00	2.
1	5	60	0.02	0.00	2.
1	6	10	0.05	0.03	31.
1	6	20	0.05	0.03	122.
1	6	30	0.05	0.03	249.
1	6	40	0.05	0.03	343.
1	6	50	0.05	0.03	390.
1	6	60	0.05	0.03	412.
1	7	10	0.05	0.03	422.
1	7	20	0.05	0.03	427.
1	7	30	0.05	0.03	429.
1	7	40	0.05	0.03	429.
1	7	50	0.05	0.03	429.
1	7	60	0.05	0.03	429.
1	8	10	0.05	0.03	429.
1	8	20	0.05	0.03	429.
1	8	30	0.05	0.03	429.
1	8	40	0.05	0.03	428.
1	8	50	0.05	0.03	428.
1	8	60	0.05	0.03	428.
1	9	10	0.05	0.03	428.
1	9	20	0.05	0.03	428.
1	9	30	0.05	0.03	428.
1	9	40	0.05	0.03	428.
1	9	50	0.05	0.03	428.
1	9	60	0.05	0.03	428.
1	10	10	0.05	0.03	428.
1	10	20	0.05	0.03	428.
1	10	30	0.05	0.03	428.
1	10	40	0.05	0.03	428.
1	10	50	0.05	0.03	428.
1	10	60	0.05	0.03	428.
1	11	10	0.05	0.03	428.
1	11	20	0.05	0.03	428.
1	11	30	0.05	0.03	428.
1	11	40	0.05	0.03	428.
1	11	50	0.05	0.03	428.
1	11	60	0.05	0.03	428.
1	12	10	0.28	0.26	646.
1	12	20	0.28	0.26	1343.
1	12	30	0.28	0.26	2301.
1	12	40	0.28	0.26	3021.
1	12	50	0.28	0.26	3372.
1	12	60	0.28	0.26	3538.
1	13	10	0.33	0.31	3669.
1	13	20	0.33	0.31	3876.
1	13	30	0.33	0.31	4127.
1	13	40	0.33	0.31	4302.
1	13	50	0.33	0.31	4388.
1	13	60	0.33	0.31	4429.
1	14	10	0.42	0.40	4527.
1	14	20	0.42	0.40	4791.
1	14	30	0.42	0.40	5146.
1	14	40	0.42	0.40	5410.
1	14	50	0.42	0.40	5538.
1	14	60	0.42	0.40	5599.
1	15	10	1.05	1.03	6240.
1	15	20	1.05	1.03	8207.
1	15	30	1.05	1.03	10903.
1	15	40	1.05	1.03	12921.
1	15	50	1.05	1.03	13907.
1	15	60	1.05	1.03	14372.
1	16	10	0.39	0.37	13952.
1	16	20	0.39	0.37	12016.
1	16	30	0.39	0.37	9258.

1 16 40	0.39	0.37	7152.
1 16 50	0.39	0.37	6124.
1 16 60	0.39	0.37	5639.
1 17 10	0.31	0.29	5330.
1 17 20	0.31	0.29	4968.
1 17 30	0.31	0.29	4566.
1 17 40	0.31	0.29	4303.
1 17 50	0.31	0.29	4174.
1 17 60	0.31	0.29	4114.
1 18 10	0.03	0.01	3821.
1 18 20	0.03	0.01	2965.
1 18 30	0.03	0.01	1799.
1 18 40	0.03	0.01	1404.
1 18 50	0.03	0.01	1348.
1 18 60	0.03	0.01	1294.
1 19 10	0.03	0.01	1243.
1 19 20	0.03	0.01	1194.
1 19 30	0.03	0.01	1146.
1 19 40	0.03	0.01	1101.
1 19 50	0.03	0.01	1057.
1 19 60	0.03	0.01	1015.
1 20 10	0.03	0.01	975.
1 20 20	0.03	0.01	936.
1 20 30	0.03	0.01	899.
1 20 40	0.03	0.01	863.
1 20 50	0.03	0.01	829.
1 20 60	0.03	0.01	796.
1 21 10	0.03	0.01	764.
1 21 20	0.03	0.01	734.
1 21 30	0.03	0.01	705.
1 21 40	0.03	0.01	677.
1 21 50	0.03	0.01	650.
1 21 60	0.03	0.01	624.
1 22 10	0.03	0.01	599.
1 22 20	0.03	0.01	575.
1 22 30	0.03	0.01	552.
1 22 40	0.03	0.01	530.
1 22 50	0.03	0.01	509.
1 22 60	0.03	0.01	489.
1 23 10	0.03	0.01	470.
1 23 20	0.03	0.01	451.
1 23 30	0.03	0.01	433.
1 23 40	0.03	0.01	416.
1 23 50	0.03	0.01	399.
1 23 60	0.03	0.01	384.
SUM	20.28	17.40	267351.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	14372.	6193.	1857.	1857.	267344.
INCHES		15.57	18.67	18.67	18.67
AC-FT		3073.	3684.	3684.	3684.

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COMBINE HYDROGRAPHS

COMBINING SUB-AREA NO. 1-6

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
7	6	0	0	0	0	1

SUM OF 6 HYDROGRAPHS AT 7

28.	27.	26.	25.	24.	23.	22.	21.	20.	19.
19.	18.	17.	16.	16.	15.	15.	14.	13.	13.
12.	12.	11.	11.	11.	10.	10.	9.	9.	9.
8.	8.	8.	7.	7.	7.	42.	157.	329.	490.
618.	728.	826.	915.	996.	1071.	1141.	1206.	1265.	1316.
1359.	1395.	1426.	1452.	1475.	1494.	1510.	1524.	1535.	1545.
1554.	1561.	1567.	1572.	1577.	1581.	1584.	1587.	1590.	1592.
1593.	1595.	1365.	2743.	4048.	5273.	6244.	7080.	7892.	8781.
9717.	10592.	11352.	12052.	12780.	13652.	14508.	15472.	16193.	16819.
19125.	21069.	25159.	28973.	32039.	34692.	36268.	35827.	33939.	32113.
30910.	29976.	29052.	27930.	26640.	25379.	24177.	23028.	21639.	19637.
17247.	15542.	14125.	12727.	11459.	10367.	9336.	8425.	7590.	6803.
6082.	5443.	4885.	4403.	3975.	3604.	3312.	3109.	2923.	2800.
2689.	2592.	2479.	2381.	2286.	2195.	2108.	2024.	1944.	1867.
1792.	1721.	1653.	1587.						

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	36268.	21424.	6684.	6684.	962491.
INCHES		14.40	17.97	17.97	17.97
AC-FT		10629.	13264.	13264.	13264.

OVN

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HYDROGRAPH ROUTING

ROUTING GREEN RIVER RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
8	1	0	0	0	0	1

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
-0.0	0.0	0.0	1	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.0	0.0	0.0	-1.

STORAGE#	17516.	18939.	19513.	20363.	20845.	22544.	23990.	25712.	27135.	27731.
OUTFLOW#	385.	925.	1955.	2582.	4074.	8782.	15251.	24547.	36098.	42484.

	TIME	EOP STOR	AVG IN	EOP OUT
1	0 10	17518.	28.	28.
1	0 20	17516.	27.	385.
1	0 30	17511.	26.	383.
1	0 40	17506.	25.	381.
1	0 50	17501.	24.	379.
1	0 60	17496.	23.	378.
1	1 10	17491.	22.	376.
1	1 20	17486.	21.	374.
1	1 30	17482.	21.	372.
1	1 40	17477.	20.	370.
1	1 50	17472.	19.	368.
1	1 60	17467.	18.	366.
1	2 10	17462.	17.	365.
1	2 20	17458.	17.	363.
1	2 30	17453.	16.	361.
1	2 40	17448.	15.	359.
1	2 50	17443.	15.	357.
1	2 60	17439.	14.	356.
1	3 10	17434.	14.	354.
1	3 20	17429.	13.	352.
1	3 30	17424.	13.	350.
1	3 40	17420.	12.	348.
1	3 50	17415.	12.	347.
1	3 60	17411.	11.	345.
1	4 10	17406.	11.	343.
1	4 20	17401.	10.	341.
1	4 30	17397.	10.	340.
1	4 40	17392.	10.	338.
1	4 50	17388.	9.	336.
1	4 60	17383.	9.	335.
1	5 10	17379.	8.	333.
1	5 20	17374.	8.	331.
1	5 30	17370.	8.	330.
1	5 40	17365.	7.	328.
1	5 50	17361.	7.	325.
1	5 60	17356.	7.	324.
1	6 10	17352.	24.	323.
1	6 20	17349.	100.	322.
1	6 30	17348.	243.	321.
1	6 40	17349.	410.	322.
1	6 50	17353.	554.	323.
1	6 60	17357.	673.	325.
1	7 10	17364.	777.	327.
1	7 20	17371.	871.	330.
1	7 30	17380.	956.	333.
1	7 40	17389.	1033.	337.
1	7 50	17400.	1106.	341.
1	7 60	17411.	1173.	345.
1	8 10	17423.	1235.	350.
1	8 20	17436.	1290.	355.
1	8 30	17450.	1337.	360.
1	8 40	17464.	1377.	365.
1	8 50	17478.	1411.	371.
1	8 60	17493.	1439.	376.
1	9 10	17508.	1464.	382.
1	9 20	17523.	1484.	388.
1	9 30	17538.	1502.	393.
1	9 40	17554.	1517.	399.
1	9 50	17569.	1529.	405.
1	9 60	17585.	1540.	411.
1	10 10	17600.	1550.	417.
1	10 20	17616.	1557.	423.
1	10 30	17632.	1564.	429.
1	10 40	17647.	1570.	435.
1	10 50	17663.	1575.	441.
1	10 60	17679.	1579.	447.
1	11 10	17694.	1583.	453.
1	11 20	17710.	1586.	459.

1	11	30	17725.	1588.	464.
1	11	40	17741.	1591.	470.
1	11	50	17756.	1593.	476.
1	11	60	17771.	1594.	482.
1	12	10	17789.	1730.	488.
1	12	20	17813.	2304.	498.
1	12	30	17853.	3395.	513.
1	12	40	17910.	4661.	535.
1	12	50	17982.	5759.	562.
1	12	60	18066.	6662.	594.
1	13	10	18160.	7486.	630.
1	13	20	18266.	8337.	670.
1	13	30	18384.	9249.	714.
1	13	40	18514.	10150.	764.
1	13	50	18654.	10967.	817.
1	13	60	18804.	11702.	874.
1	14	10	18962.	12416.	966.
1	14	20	19129.	13216.	1265.
1	14	30	19304.	14130.	1579.
1	14	40	19487.	15040.	1908.
1	14	50	19677.	15832.	2076.
1	14	60	19875.	16500.	2222.
1	15	10	20084.	17472.	2376.
1	15	20	20320.	19597.	2550.
1	15	30	20598.	23114.	3310.
1	15	40	20919.	27066.	4278.
1	15	50	21273.	30506.	5260.
1	15	60	21653.	33366.	6313.
1	16	10	22047.	35480.	7405.
1	16	20	22434.	36047.	8478.
1	16	30	22788.	34383.	9875.
1	16	40	23098.	33026.	11259.
1	16	50	23368.	31511.	12470.
1	16	60	23608.	30443.	13544.
1	17	10	23822.	29514.	14499.
1	17	20	24009.	28491.	15352.
1	17	30	24167.	27285.	16207.
1	17	40	24297.	26010.	16910.
1	17	50	24402.	24778.	17474.
1	17	60	24483.	23603.	17913.
1	18	10	24542.	22333.	18230.
1	18	20	24574.	20638.	18403.
1	18	30	24574.	18442.	18406.
1	18	40	24548.	16394.	18261.
1	18	50	24502.	14833.	18015.
1	18	60	24441.	13426.	17688.
1	19	10	24367.	12093.	17285.
1	19	20	24282.	10913.	16828.
1	19	30	24189.	9851.	16328.
1	19	40	24091.	8881.	15794.
1	19	50	23987.	8008.	15236.
1	19	60	23880.	7196.	14757.
1	20	10	23769.	6442.	14260.
1	20	20	23655.	5762.	13752.
1	20	30	23540.	5164.	13239.
1	20	40	23425.	4643.	12725.
1	20	50	23311.	4187.	12214.
1	20	60	23199.	3790.	11711.
1	21	10	23088.	3458.	11217.
1	21	20	22981.	3211.	10739.
1	21	30	22878.	3010.	10277.
1	21	40	22779.	2862.	9834.
1	21	50	22684.	2744.	9410.
1	21	60	22594.	2635.	9005.
1	22	10	22507.	2530.	8619.
1	22	20	22422.	2430.	8445.
1	22	30	22340.	2333.	8216.
1	22	40	22259.	2241.	7992.
1	22	50	22180.	2152.	7773.
1	22	60	22103.	2066.	7560.
1	23	10	22027.	1984.	7351.
1	23	20	21954.	1905.	7147.
1	23	30	21882.	1829.	6948.
1	23	40	21812.	1757.	6753.
1	23	50	21743.	1687.	6563.
1	23	60	21676.	1620.	6378.
		SUM			662887.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	18406.	14063.	4603.	4603.	662887.
INCHES		9.45	12.38	12.38	12.38
AC-FT		6577.	9135.	9135.	9135.

OVF

STATION 8

INFLOW=I<, OUTFLOW=O< AND OBSERVED FLOW=*<

0. 5000. 10000. 15000. 20000. 25000. 30000. 35000. 40000. 0.

1 0 101
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1 0 3010
1 0 4010

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RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	1	9714.	6001.	1847.	1847.	3.92
HYDROGRAPH AT	2	6834.	4422.	1358.	1358.	2.90
HYDROGRAPH AT	3	3548.	1742.	520.	520.	1.06
HYDROGRAPH AT	4	4811.	2532.	757.	757.	1.56
HYDROGRAPH AT	5	2413.	1155.	345.	345.	0.70
HYDROGRAPH AT	6	14372.	8193.	1857.	1857.	3.70
6 COMBINED	7	36268.	21424.	6684.	6684.	13.84
ROUTED TO	8	18406.	14063.	4603.	4603.	13.84

APPENDIX E

Information as Contained in the National Inventory of Dams